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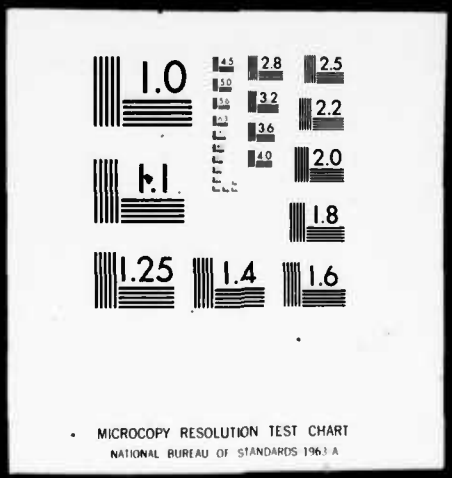

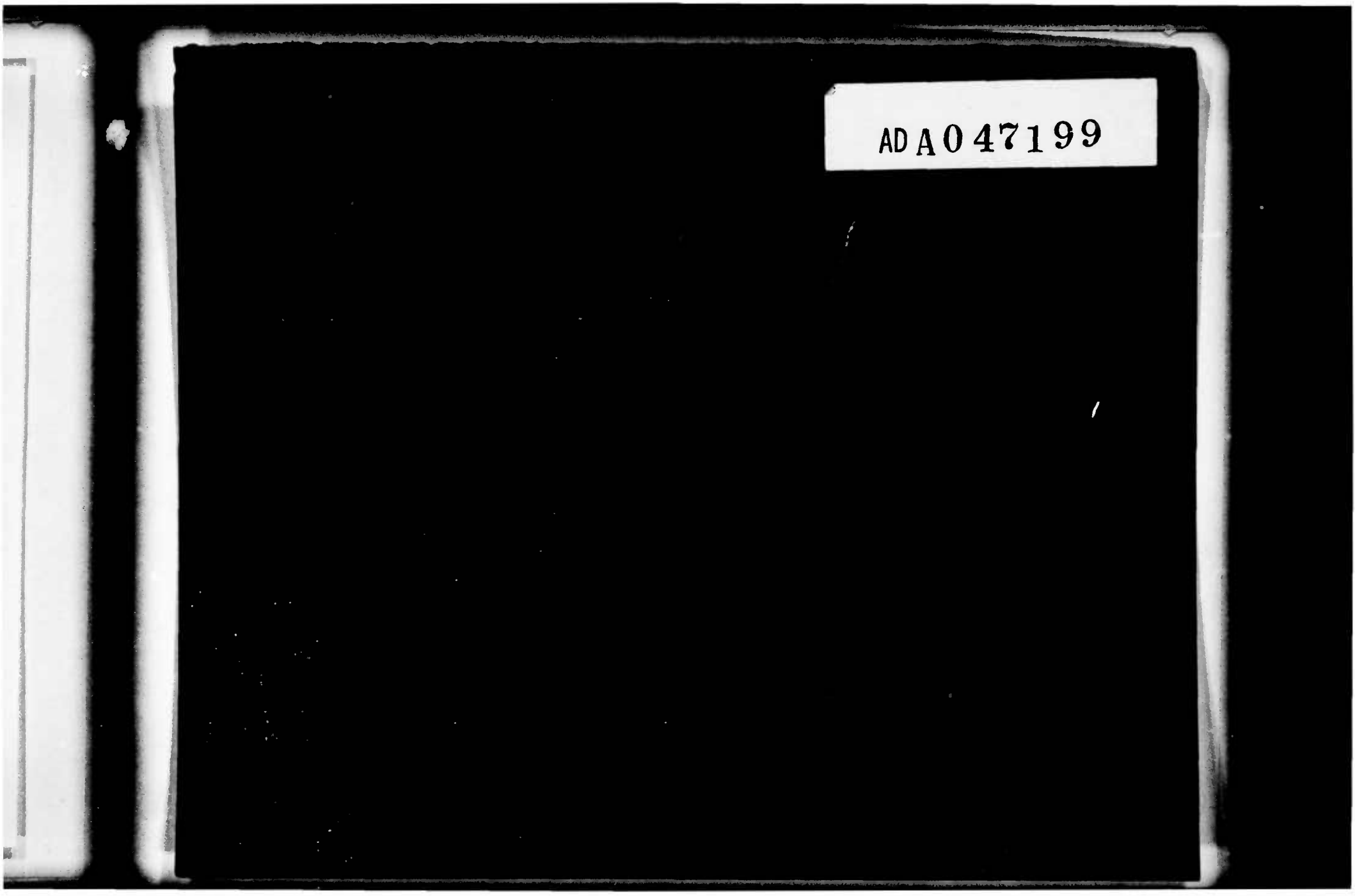

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Fallout shelter capabilities for both local and relocated populations is a critical requirement of a crisis relocation plan. Upgrading "host" area structures or building expedient shelters can be greatly enhanced with effective use of equipment. The report presents guidelines and data enabling planners to determine requirements and adequacy of available equipment for providing needed shelter during a three day crisis period. Associated manual tasks and other requirements are also defined.

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PREFACE

This report on the utilization of equipment during a Crisis Relocation has been prepared by Jacobs Associates of 500 Sansome Street, San Francisco, California under Contract No. DCPA01-76-0306 dated June 2, 1976 with the Defense Civil Preparedness Agency.

It deals primarily with host area requirements and applications in providing adequate fallout shelter protection for both local residents and relocatees as may be required during a crisis period evolving from a sharp deterioration of international relations.

It defines upgrading and expedient construction tasks and provides methods and examples of how available equipment can be effectively used to complete those tasks within a 3 day crisis period.

Appreciation is expressed for the cooperation and help in making the study offered by Mr. M.A. Pachuta (COTR). In assessing the availability of equipment in Fremont County, Colorado, the study team was aided by Mr. Frank Mollner, Region 6, Mr. William Giordano of Canon City, Colorado, and Mr. Robert McWilliams of Colorado City.

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INTRODUCTION

There are two basic Civil Preparedness strategies for protecting populations threatened by major hazards. One is to provide the best protection possible with the population essentially "in place", at or near their homes, schools and places of work. The second is for people to leave the threatened area if time allows.

The two strategies apply in both peacetime and attack caused emergencies. Tornado and earthquake threats are cases where people must seek in-place protection promptly due to the swiftness with which the threat develops.

In the case of hurricanes or floods, however, there is usually a period of hours or even days that can be, and often is, used to relocate or evacuate people from hazardous areas. This strategy also applies where there is danger of release of chlorine or other toxic substance, and evacuation of threatened areas could be needed should a serious accident at a nuclear power reactor cause airborne release of radioactive material.

Crisis Relocation Plans (CRP) are being developed for the contingency of a severe international situation in which it could be desirable for people to relocate temporarily from major "risk" areas that might suffer the direct effects of nuclear weapons (e.g. blast, heat) to outlying "host" areas, should the crisis escalate to an attack. These CRP's include guidelines for providing or improving host area fallout shelter capacities and other capabilities which would be required for

both local residents and relocatees.

This study is directed primarily toward the utilization of construction equipment in providing adequate host area shelter facilities during a three day crisis period that might develop due to a sharp deterioration of international relations.

SECTION 1

EQUIPMENT REQUIREMENTS

1.1 GENERAL

Various guidelines and planning techniques have been prepared which present different steps, procedures and requirements for moving large populations from a "risk area" to outlying "host areas" in times of an international crisis. These Crisis Relocation Plans (CRP); described in detail in References 1 and 2, contemplate the use of heavy equipment as a vital resource for successful completion of certain preparatory tasks.

A host area could include numerous communities, towns or cities within counties contiguous with the risk area and within a range of 50 to several hundred miles. Their location and size are defined by various parameters such as described in the DCPA Attack Environment Manuals (Reference 3) and other reports. In general they would be more rural in nature than their risk area counterparts and would provide lodging, feeding and general care facilities for evacuees during the crisis period. In the event of an attack, the host area must also provide adequate fallout shelter for both local and relocated populations. Individuals essential for maintaining critical services and facilities within the risk area could be transported to and from the host area as required.

In most areas, general care facilities could be provided within existing buildings with little or no alterations requir-

ing the use of heavy equipment. However, it is unlikely that any host area would have shelter capacities needed for a CRP. Therefore it will be necessary to either upgrade existing structures or build expedient type shelters. Within the concept that a "crisis build-up" would span a period of only about three days, it is apparent that preparation of needed shelter space would be greatly enhanced with the effective use of heavy equipment. This, as well as other equipment requirements for both risk and host areas must be planned and coordinated for successful accomplishment of CRP goals. The initial requirement would be to upgrade and improve host area shelter capabilities. Should an attack occur, equipment would be required immediately for rescue, debris removal and other emergency operations within the risk area. Consequently, equipment needs must be considered with respect to both the crisis and early post-attack periods. Some equipment would be suitable in both instances, some would not. In most cases the tasks or requirements within the host area are less demanding or restrictive with respect to type of equipment used than those within the risk area during the early post-attack period. It is likely that similar types and possibly quantities of equipment would be found in both areas. Actual logistics or movement between the two areas will depend on separate evaluations of task requirements and priorities.

During a crisis build-up it is assumed that equipment within the risk area would be mobilized at multiple staging areas (MSA's) which would likely be away from potential targets

and in the general direction of the host areas. Subsequent movement to specific host area locations would be made as required. Some equipment not suitable for risk area emergency tasks (small rubber tired loaders, etc.) could be moved directly to the host area. In all probability the time interval during which "risk area" equipment would be available for "host area" tasks would be limited to one or two days as compared to assumed crisis build-up time of three days. On the other hand, equipment within the host area could be made available to start host area tasks within a few hours. Since tasks would likely be scattered over a large area, priorities should be established which take into account task location and the potential availability of risk area equipment at some later time. If an attack appears imminent, it may be necessary to make a decision as to whether host area tasks should be completed or equipment made available for emergency operations within the risk area - moved back to a risk area MSA. Large crawler type equipment which is more effective for tasks such as debris clearing might be transferred initially from a host area to the risk area.

The movement of equipment to MSA's and between host and risk areas will be a major problem during the crisis period. Rail haulage may be possible, but could be very restrictive. Using low-bed trucks or self-propelled equipment on highways would be more flexible but would probably encounter heavy traffic conditions and add to the congestion. Even though a three-day crisis period is assumed it would be difficult to

move any large amount of equipment to and from locations which could be several hundred miles apart and still expect effective utilization for specific tasks. This is especially true when considering the mass movement of people and supplies which must be accommodated over the same transportation routes. With the exception of equipment movement to MSA's, or in cases where host area tasks are within a radius of 40 to 60 miles of a MSA (where rubber-tired equipment could move back and forth under its own power), only those units not specifically required for tasks within an area would be considered for transfer. If studies (inventories, task requirements, etc.) indicate that this need exists it would be advisable to make equipment transfers before starting the actual relocation of people and supplies.

Equipment requirements for both areas are discussed in the following paragraphs. Equipment production and availability are discussed in subsequent sections.

1.2 HOST AREA TASKS

Facilities within host areas must accommodate both local residents and risk area evacuees, which could greatly exceed the local population. Previously mentioned references indicate requirements for different facilities -- lodging, feeding, sanitary, medical, shelter, etc. CRP planning generally considers congregate care facilities on the basis of 40 square feet per person, shelter facilities on basis of 10 square feet per person. Some structures may serve both purposes, others may

not. Where shelter and congregate care facilities are in separate structures, they should be within reasonable walking distance of each other.

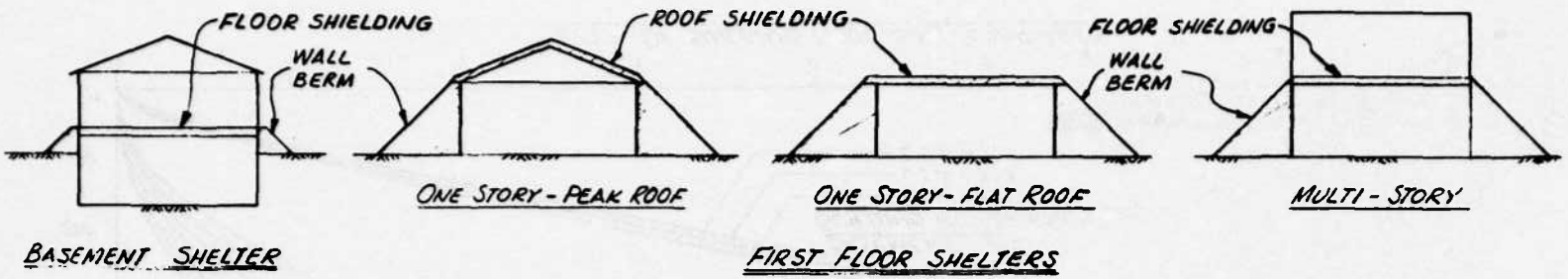
With the exception of transportation vehicles; buses, trucks and cars, equipment requirements will consist of: 1) upgrading existing structures for shelter protection, 2) constructing expedient shelters and 3) providing or improving sanitary, water, ventilation or other facilities. It is assumed that additional emergency and utility vehicles such as fire trucks, garbage trucks and ambulances will be brought in from the risk area. In some instances, snow removal or other road maintenance equipment will be required.

1.2.1 Upgrading Structures: Some structures within a host area will probably qualify as a shelter facility within the standards of the National Shelter Survey (NSS). It is likely, however, that they would provide only a small percentage of shelter space needed and it may also be necessary to upgrade some of them. Subsequent DCPA studies indicate that many structures not qualified under NSS could provide protection factors (PF) of 40 or more with a minimum amount of earth or sandbag type shielding placed around the walls and on the roofs or lower floors of the structure. An actual experiment as to how light structures - in this case a family residence - could be upgraded is detailed and illustrated in Reference 4.

Although many structures could be upgraded, general priorities based on use and types of buildings have been established

which serve as a guide in designating those structures to be used. In order of preference they are 1) non-residential, commercial type buildings, 2) public buildings and 3) private residential. Needed shelter space could probably be obtained by upgrading only a portion of available structures. The planner would make his selection from the host area survey listings showing the most likely candidates for upgrading.

The amount of material required to upgrade a structure depends on the physical dimensions and characteristics of the building, the areal configuration of the surrounding structures and the magnitude of the expected fallout threat. Figure 1 shows several possibilities and gives an indication of quantities required for wall (berm) and roof or intermediate floor shielding. Quantities of material needed to upgrade typical single story buildings are shown on Figure 2. The ratio of cubic yards of shielding material per shelter space varies considerably (percentage wise) depending on type of structure being upgraded and the amount of usable space within the structure. Table 1 presents a general indication of this relation based on various assumptions of building types and configurations. Although these assumptions may or may not be typical, a planner could develop a similar table which would reflect average conditions in his area. Such a table would serve as a useful guide for individuals making a shelter survey. For instance, if an upgradable structure was identified as being similar to a class V building and the amount of usable space determined as 70%, then the amount of shielding


FLOOR SHIELDING
WALL BERM
ROOF SHIELDING
FLOOR SHIELDING
WALL BERM
ONE STORY - PEAK ROOF
ONE STORY - FLAT ROOF
MULTI - STORY
BASEMENT SHELTER
FIRST FLOOR SHELTERS

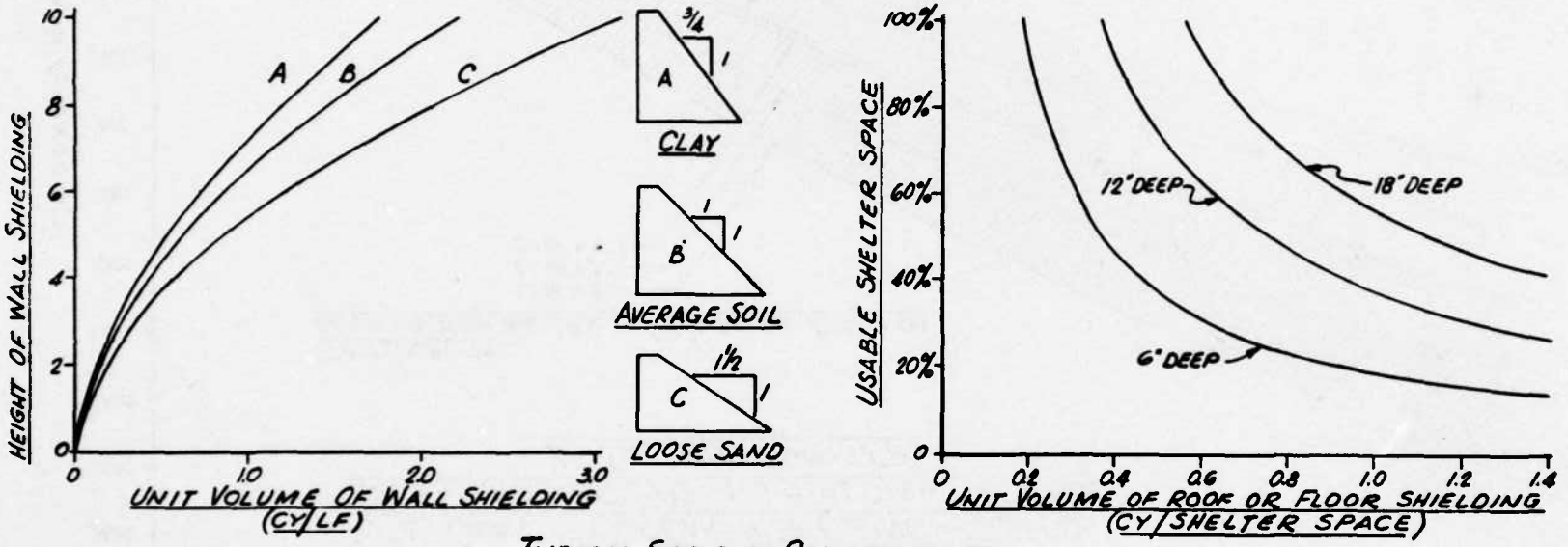

HEIGHT OF WALL SHIELDING
UNIT VOLUME OF WALL SHIELDING (CY/LF)
A
B
C
3/4
1
CLAY
AVERAGE SOIL
1½
LOOSE SAND
USABLE SHELTER SPACE
12" DEEP
18" DEEP
6" DEEP
UNIT VOLUME OF ROOF OR FLOOR SHIELDING (CY/SHELTER SPACE)
TYPICAL SHIELDING REQUIREMENTS

Figure 1

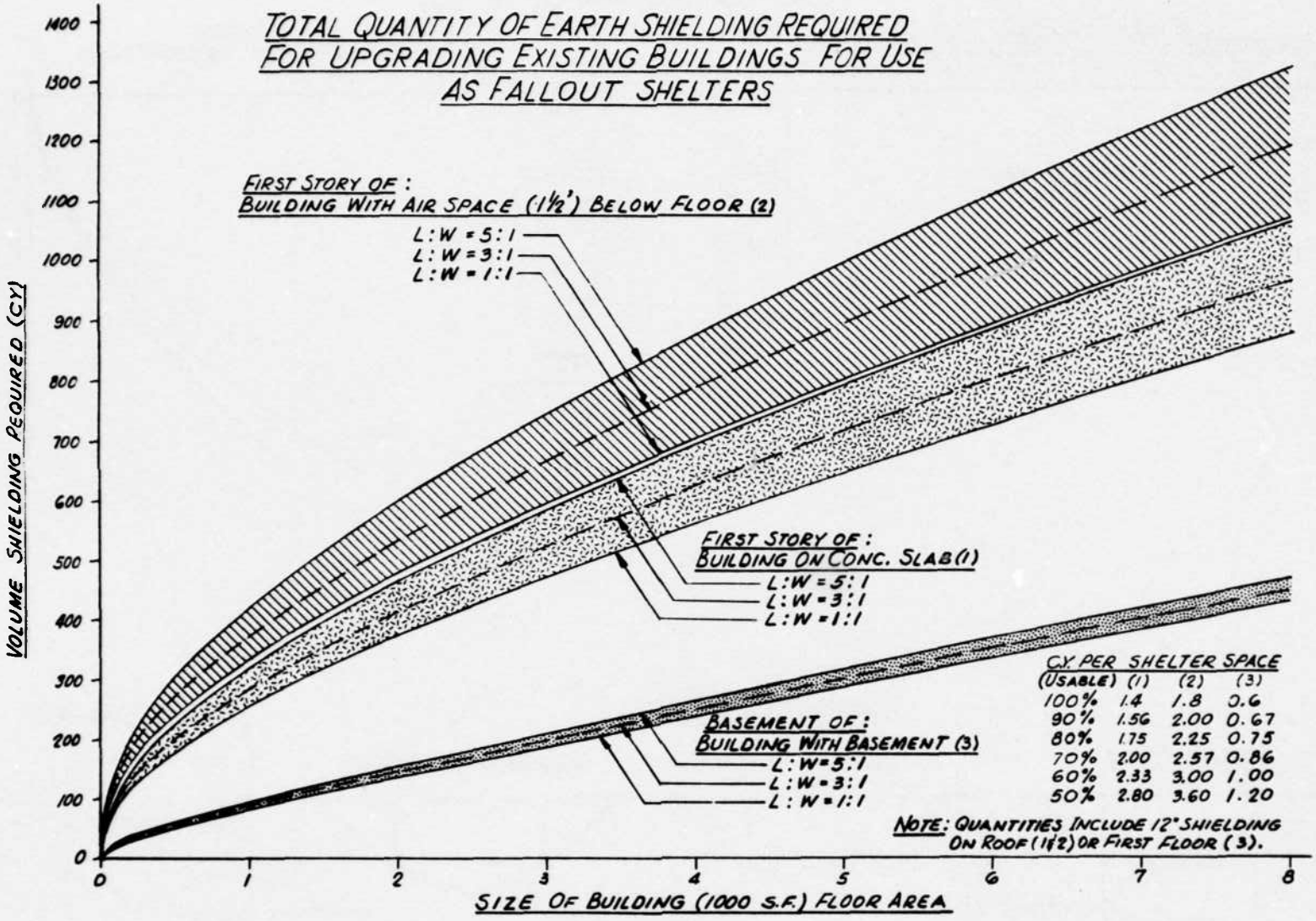

TOTAL QUANTITY OF EARTH SHIELDING REQUIRED FOR UPGRADING EXISTING BUILDINGS FOR USE AS FALLOUT SHELTERS
VOLUME SHIELDING REQUIRED (CY)
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
FIRST STORY OF : BUILDING WITH AIR SPACE (1½') BELOW FLOOR (2)
L:W = 5:1
L:W = 3:1
L:W = 1:1
FIRST STORY OF : BUILDING ON CONC. SLAB (1)
L:W = 5:1
L:W = 3:1
L:W = 1:1
BASEMENT OF : BUILDING WITH BASEMENT (3)
L:W = 5:1
L:W = 3:1
L:W = 1:1
C.Y. PER SHELTER SPACE
(USABLE) (1) (2) (3)
100% 1.4 1.8 0.6
90% 1.56 2.00 0.67
80% 1.75 2.25 0.75
70% 2.00 2.57 0.86
60% 2.33 3.00 1.00
50% 2.80 3.60 1.20
NOTE: QUANTITIES INCLUDE 12" SHIELDING ON ROOF (1½) OR FIRST FLOOR (3).
0
1
2
3
4
5
6
7
8
SIZE OF BUILDING (1000 S.F.) FLOOR AREA

Figure 2

SUGGESTED BUILDING CLASSIFICATION FOR FALLOUT SHELTER UPGRADING													
CLASSIFICATION	CHARACTERISTICS										SHIELDING REQUIRED* CU. YD. PER SPACE		
	SHELTER LEVEL		NUMBER OF STORIES		ADJACENT STRUCTURES		SHIELDING LOCATIONS				USABLE SPACE		
	BELOW GROUND	GROUND LEVEL	ONE	MULTI	SINGLE	ATTACHED	BASMENT ENTR.	WALL BERM	GROUND FLOOR	ROOF	90%	70%	50%
MASONRY OR STEEL FRAME & CONCRETE BUILDINGS													
I	x	-	-	x	x	x	x	-	-	-	0.2	0.3	0.4
II**	x	-	-	x	x	x	x	x	-	-	0.3	0.4	0.5
III	x	-	x	-	x	x	x	x	x	-	0.4	0.6	0.8
IV	-	x	-	x	-	x	-	x	-	-	0.6	0.8	1.0
V	-	x	-	x	x	-	-	x	-	-	1.0	1.3	1.8
VI	-	x	x	-	-	x	-	x	-	x	1.1	1.4	2.0
VII	-	x	x	-	x	-	-	x	-	x	1.2	1.5	2.2
WOOD FRAME OR SHEET METAL BUILDINGS													
VIII	x	-	x	x	-	x	x	x	x	-	0.6	0.8	1.0
IX	x	-	x	x	x	-	x	x	x	-	0.7	0.9	1.2
X	-	x	x	x	-	x	-	x	-	x	1.2	1.5	2.2
XI	-	x	x	x	x	-	-	x	-	x	1.6	2.0	2.8
XII***	-	x	x	x	-	x	-	x	-	x	1.5	1.9	2.7
XIII***	-	x	x	x	x	-	-	x	-	x	2.0	2.6	3.6

*Shielding volumes given apply to essentially square buildings over 3000 sq.ft. For smaller buildings and other length width ratio use modifying factors given below. Quantities include 12" depth of horizontal shielding.
**Similar to Classification I except first floor level is about 2 feet above ground level.
***With crawl space.

Building Size Factors:
- Area 2000 - 3000 sq ft, Add 10%
- Area 1500 - 2000 sq ft, Add 25%
- Area 1000 - 1500 sq ft, Add 50%
- Area 500 - 1000 sq ft, Add 100%

Length/Width Factors:
- L/W = 3:1, Add 10%
- L/W = 5:1, Add 20%

,m

Table 1

material per shelter space would be 1.3 cu yd. If the 70% usable space represented 210 shelter spaces, the total amount of material would be 273 cu yd. In this instance the resulting PF would be about 100. If predetermined shelter use plans indicated a higher or lower PF as providing satisfactory protection, then the shielding could be adjusted accordingly.

Various surveys have been made which include the determination of total amount of shielding required for specific structures (References 1 and 5). Those surveys, plus other DCPA studies indicate a general requirement of about one cubic yard of shielding material for one shelter space with a protection factor of about 40. The volume of shielding material to be handled in any particular host area can be determined either from actual surveys or based on a general requirement of 1 cu yd per space. This choice would be made by the planner depending on available time and staff and degree of detail deemed necessary. In making an overall evaluation of equipment utilization it would probably be sufficient to use the general requirement. For instance, if 60,000 shelter spaces were needed, the equipment requirement would be based on handling 60,000 cubic yards of earth. In final determinations, however, factors similar to those on Table 1 can be used to more nearly reflect actual quantities needed for different structures; i.e. basement shelters as opposed to above ground shelters. No distinction is made between a bank cubic yard and a loose cubic yard. In most instances all material will be handled twice.

It is also necessary to make some evaluation as to where and how the earth is to be placed; against outside walls, around basement openings, on roofs or intermediate floors. As a general guide, it can be assumed that about 60% of total shielding will be placed as berms against walls, the remaining 40% to be placed on roofs or intermediate floors. The areal location or proximity of the structure being upgraded with respect to other buildings has an effect on the requirement. Equipment movement around an isolated building is different than between closely spaced buildings. Figure 3 is a suggested format that could be used to obtain data needed to determine upgrading requirements.

In addition to knowing the quantity and placement requirement (sides or roof, isolated structures, etc.) the source and type of shielding material must be known. Although material such as masonry units could be used if available, this study considers earth as the primary material to be used for shielding. Ideally, this material would be available in close proximity of the structure and located in sufficient quantities uniformly around its perimeter. However, this situation would most likely be found only in residential areas which are considered least desirable for upgrading. In commercial areas where the source may be several hundred yards away or in areas where upgradable structures are scattered, it would be advisable to use a common source or borrow pit and haul material to each structure. The use of a common borrow pit has the following advantages: 1) it permits a concentration of equipment

UPGRADABLE SHELTER SURVEY

RISK AREA _____ STD. LOC. _____ BLDG. TITLE _____

HOST AREA _____ FAC. NO. _____ BLDG. USE _____ DATE OF SURVEY _____

ROUGH PLAN SKETCH OF AREA:
(Show approx. dimensions, abutting buildings, locations of doors and windows, and internal partition arrangement)

DESCRIPTION:
Type of construction _____
Number of floors above ground _____
Basement _____ Crawl space _____

(A_T) Total floor area at shelter level ____

% of floor area available for shelter ____

(S) No. of shelter spaces @ 10 S.F. ____

Special Notes _____

CALCULATION OF SOIL SHIELDING REQUIREMENTS:

(L) Length of building walls requiring shielding ____ LF

(K_L) Unit volume of wall shielding (from Figure 1) ____ CY/LF

(V_L) Total wall shielding $V_L = L \times K_L$ ____ CY

Depth of roof (or floor) shielding ____ IN

(K_A) Unit volume of roof shielding (from Figure 1) ____ CY/SP

(V_A) Total roof (or floor) shielding $V_A = S \times K_A$ ____ CY

(V_T) Total shielding required $V_T = V_L + V_A$ ____ CY

(V_S) Shielding required per shelter space $V_S = V_T \div S$ ____ CY/SP

Shielding to be placed by machine ____ CY

Shielding to be placed by hand ____ CY

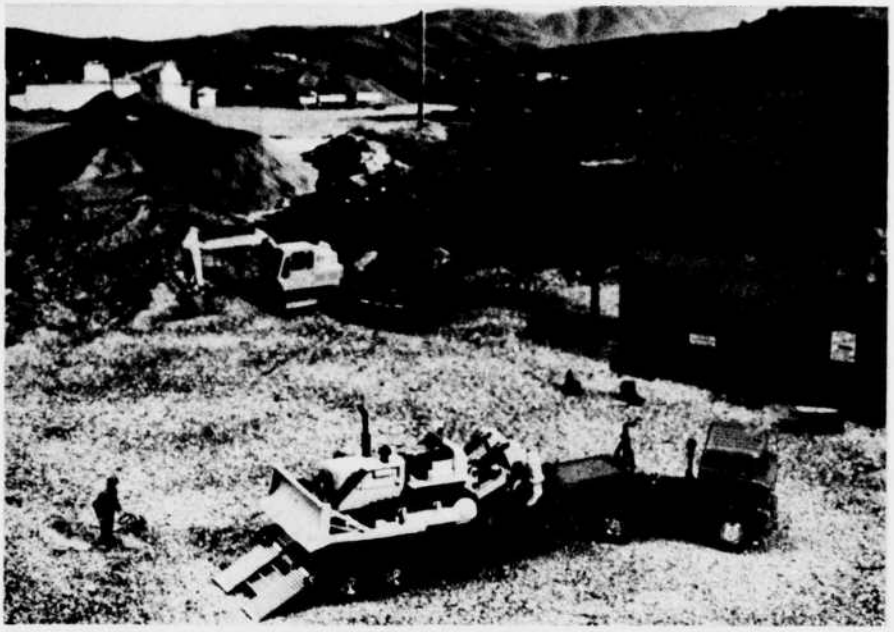
Figure 3

effort, 2) excavation is limited to a specific area, 3) pit can usually be located so as to utilize best shielding material, 4) preliminary efforts such as clearing would be minimized and 5) the subsequent dumping of individual piles of material around the structure will facilitate hand or equipment placing operations. The overall efficiency of handling 10,000 - 20,000 cu yd or more of earth material with large equipment from a single source is greater than when handling the same quantity at many different locations. Borrow pits could be vacant lots or possibly parks or other open areas within or near the host area community. In some instances, trees and other landscaping, pavements or even buried utilities could greatly hinder the use of an otherwise acceptable source. Although the requirement of 1 cu yd per shelter space seems incidental, upgrading 100,000 spaces is a major undertaking requiring the excavation of over 6 feet of earth from a 10 acre site. Whether the material is soft or hard (frozen), available in large or small quantities; above or below the water table, and other conditions should be noted. (Material below a water table would not be suitable for shielding.) Surveys or other investigations should be made to obtain this type of information.

When placing shielding material on roofs or intermediate floors, it will first be necessary to determine whether or not the structure can withstand the additional loading. If not, internal shoring and bracing will be required before shielding is placed. Structural reactions to earth loading on a residential type roof are given in Reference 4.

Equipment usage and effort required to upgrade a structure could vary considerably depending on the various factors and conditions mentioned above. However, there are basic operations or tasks which are considered in evaluating all upgrading requirements, i.e. digging, loading, hauling and placing. Figures 4 and 5 illustrate typical dig and load operations at a borrow pit. A sequence of operations used in upgrading a large public building such as a school is shown by Figure 6. Figure 7 shows a similar sequence for a small isolated building. Although these figures illustrate the general use of equipment for upgrading structures, there could be many variations within a particular host area. Manual operations such as placing protective coverings over windows or other openings; making entrance ways or placing waterproof membranes will also be required. In some cases, the actual digging, hauling and placing of shielding material could be accomplished with manual labor, but for purposes of this study it is assumed that such labor is kept at a minimum. Exceptions would be in placing shielding on sloping roofs, intermediate floors or other areas unaccessible to equipment or where the use of equipment would be impractical.

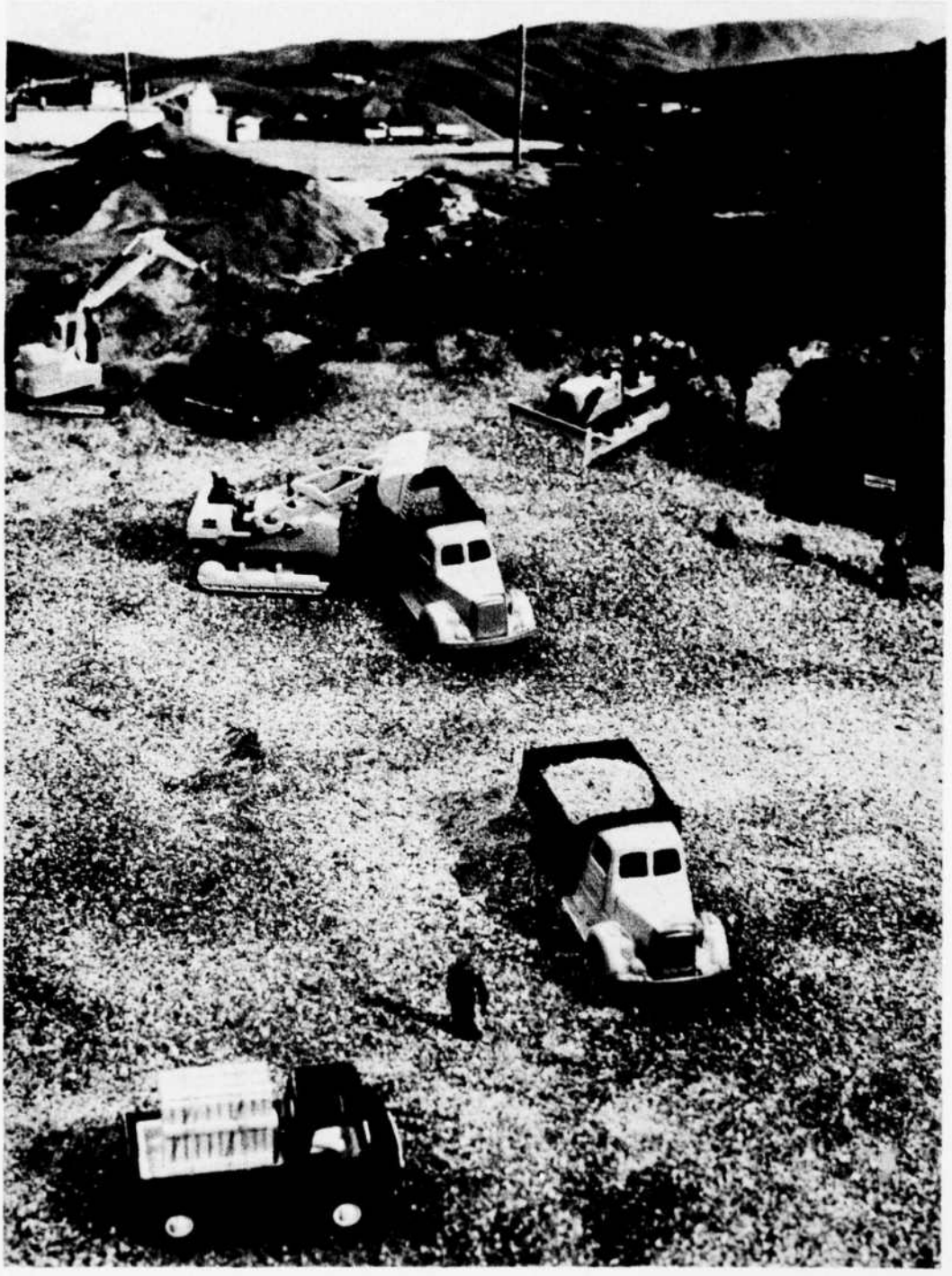
In most instances the digging, loading, and hauling operations will account for the major portion of equipment use in the upgrading process. Except where large or continuous berms are required, (Figure 6) the use of equipment for placing will be relatively inefficient compared to other operations; oftentimes being limited to production obtained by manual labor. Due



UNLOADING CRAWLER DOZER

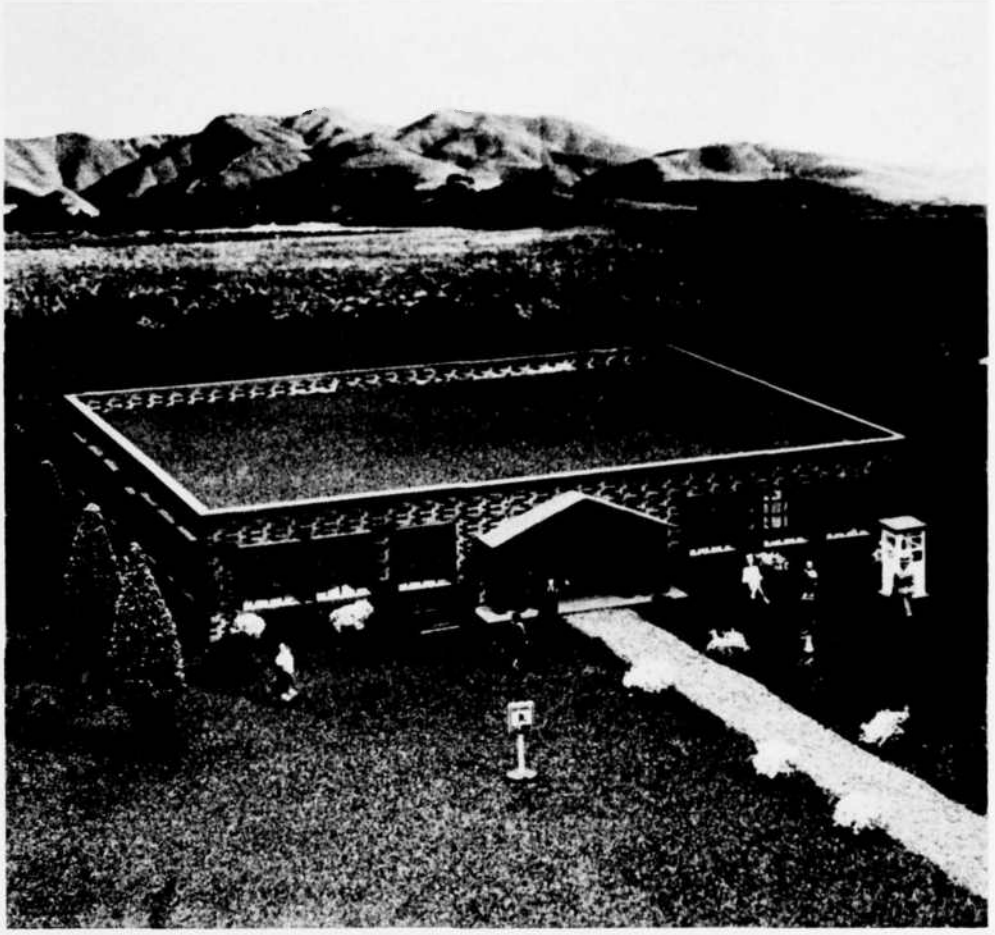
EXCAVATING AND LOADING TRUCKS

Figure 4 - EXCAVATING SHIELDING SOIL AT BORROW AREA



EXCAVATING - HAULING - LOADING
TASKS AT BORROW AREA

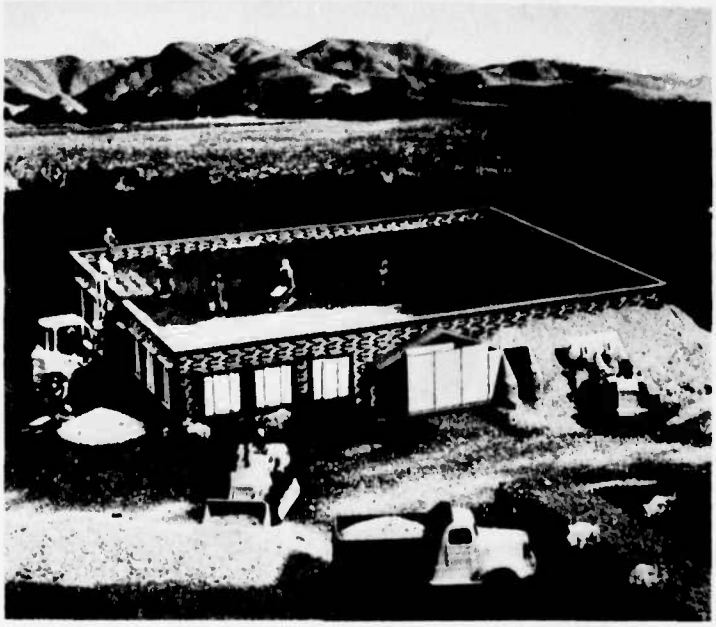
Figure 5 - HAULING SOIL FROM BORROW AREA



MAINTOWN HIGH SCHOOL
UPGRADABLE STRUCTURE
CAPACITY: 400 FALLOUT SHELTER SPACES

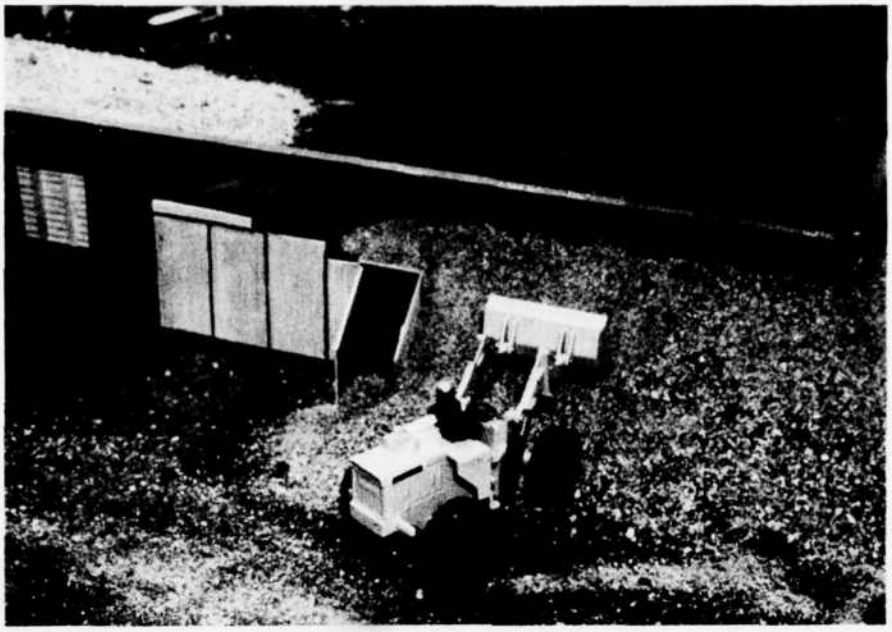
Figure 6 - PLACING SHIELDING FOR PUBLIC BUILDING

PRELIMINARY SHIELDING ACTIVITIES
DELIVERING SOIL AND EQUIPMENT
AND BOARDING WINDOWS

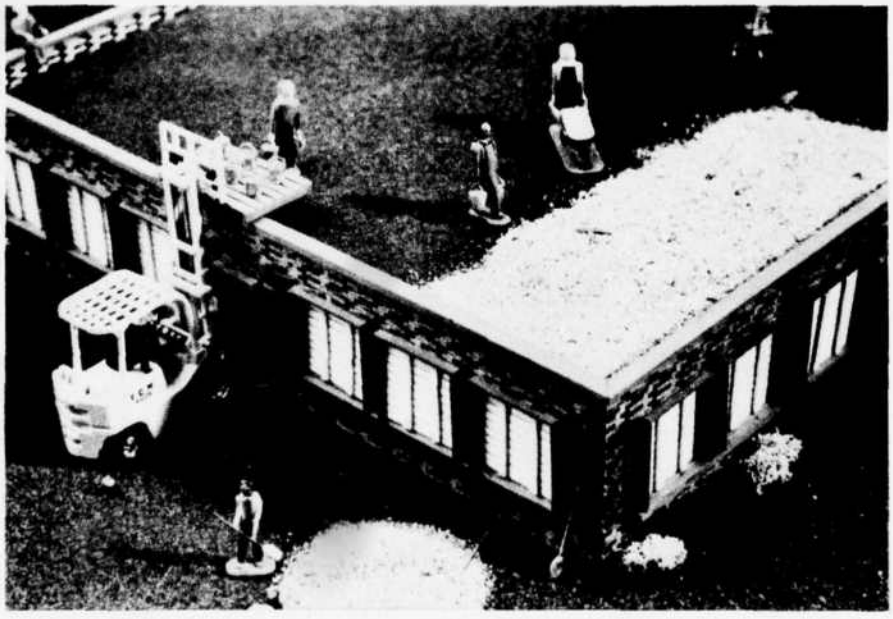


PLACING WALL BERM BY MACHINE
AND ROOF SHIELDING BY HAND

Figure 6 (continued)

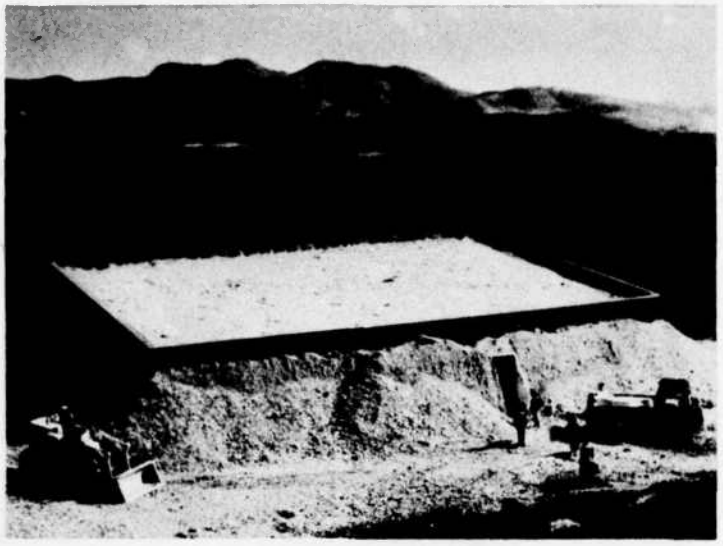


CLOSEUP OF LOADER PLACING WALL BERM

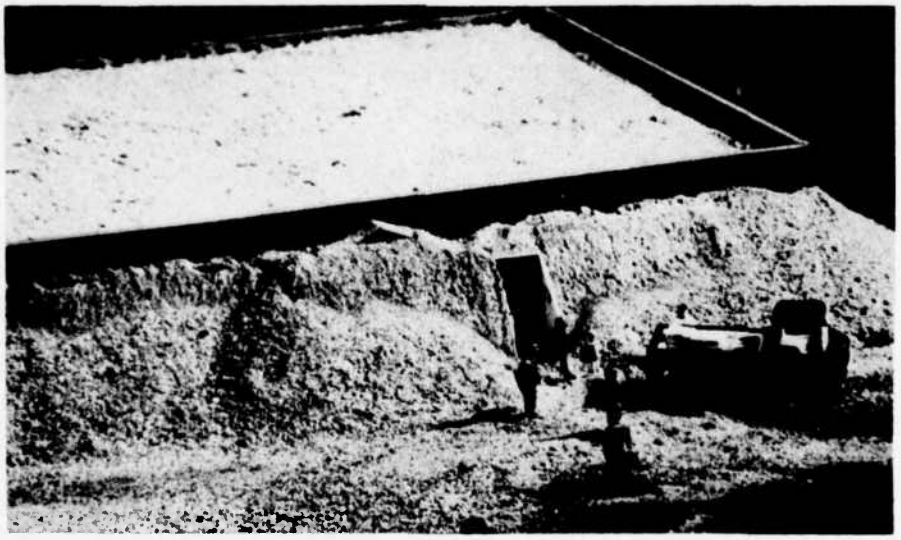


CLOSEUP OF HAND PLACING ROOF SHIELDING

Figure 6 (continued)



SCHOOL WITH ALL SHIELDING IN PLACE



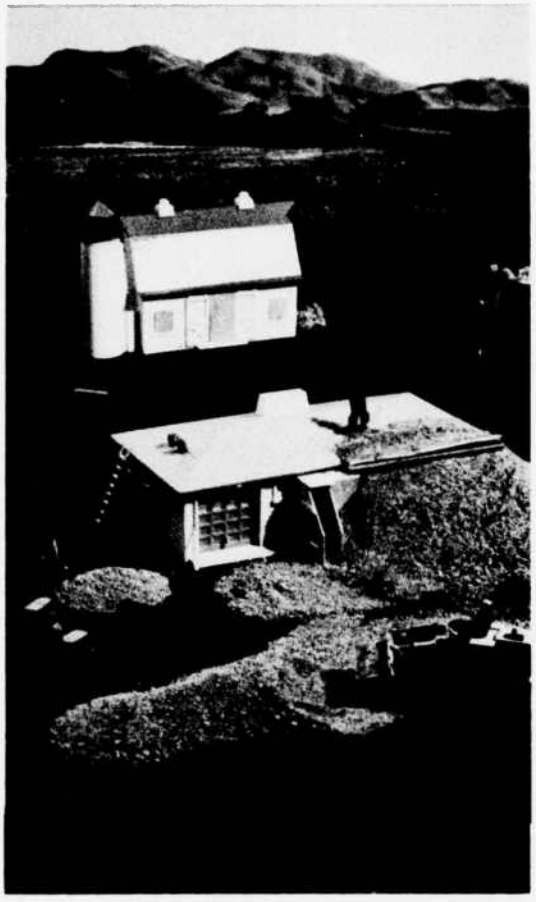
PEOPLE AND SUPPLIES ENTERING SHELTER

Figure 6 (continued)

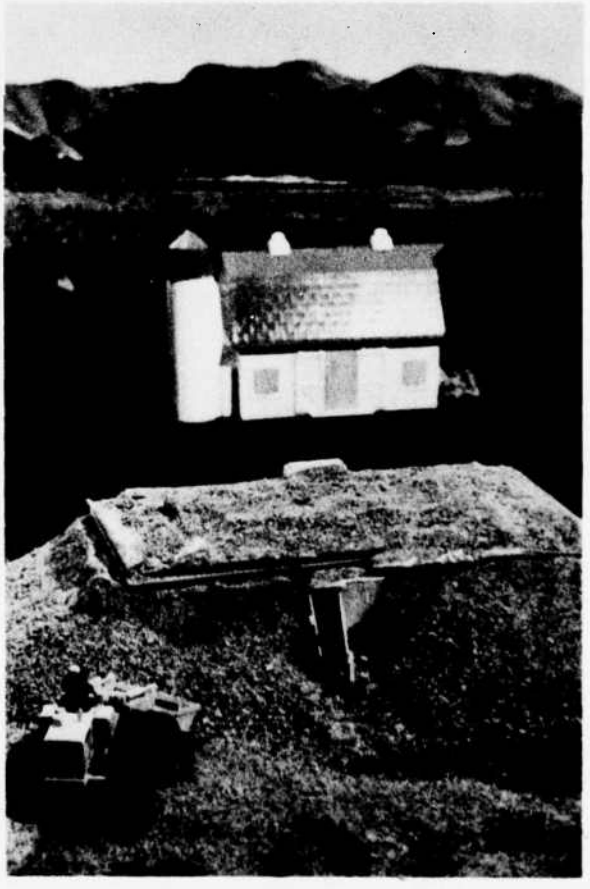
SMITH'S FARM
UPGRADABLE STRUCTURE
CAPACITY: 100 FALLOUT
SHELTER SPACES

PRELIMINARY SHIELDING
ACTIVITIES - SOIL DELIVERY,
BOARDING WINDOWS

Figure 7 - PLACING SHIELDING FOR SMALL ISOLATED BUILDINGS



PLACING WALL BERM BY
FRONT END LOADER AND
ROOF SHIELDING BY HAND



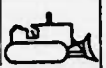
FARMHOUSE WITH ALL
SHIELDING IN PLACE

Figure 7 (continued)

to this, upgrading tasks are considered in parts or categories: the dig and load operation; hauling material to and around the structure, and the actual placing or shielding operation.

Types of tasks that could be anticipated within different host areas are listed on Table 2. Combinations of operations, which are identified by a letter code (Task A using a suffix of either H, hard material, or S, soft material) would be used as required. The table also gives a general indication of the type of equipment most suitable for completing the particular tasks. The right hand columns show the approximate percentage of material to be placed with equipment or by hand during the actual shielding operation. The following paragraphs discuss the different operations and requirements. Tasks L, M, N and P are discussed in paragraph 1.4. Use of manual labor is discussed in Section 2.

Digging and loading would be accomplished with shovels, backhoes or front-end loaders. Bulldozers could be used to push material into piles for the shovels or loaders and may be required to rip or loosen the material if the ground is frozen or hard. If the source is near the facility to be upgraded, front-end loaders could also haul the material to the structure but increased haul distance makes this type of operation inefficient. Since some of the material will be placed by hand labor, it is desirable that it be well broken or loosened for ease in handling. Mechanical digging and loading helps in this respect. The material will be obtained either from borrow pits or from a site source (adjacent to structure). The planner

TASK DEFINITION											
GENERAL WORK CATEGORY	TASK CODE	DEFINITION	EQUIPMENT USE (EFFICIENCY)							PORTION OF WORK	
			DUMP TRUCK	BACK-HOE	SHOVEL	DOZER		LOADER		BY HAND	BY MACHINE
						LARGE	SMALL	LARGE	SMALL		
											
EXCAVATE, LOAD & HAUL SHIELDING SOIL FROM BORROW AREA	A	Excavate A_S (Soft Earth) A_H (Hard Earth)	○	●	●	●	◑	◑	◑	0	100%
	B	Load Trucks	◑	◑	◑	○	○	◑	◑	0	100%
	C	Haul to Shelter Site	◑	○	○	○	○	○	○	0	100%
UPGRADING BLDGS:		Place Shielding:	○	○	○	◑	●	◑	●		
1. USE SOIL FROM BORROW AREA	D	Separate Bldg.-No Basement								30%	70%
	E	Separate Bldg.-W/Basement								60%	40%
	F	Attached Bldg.-No Basement								40%	60%
	G	Attached Bldg.-W/Basement								80%	20%
2. USE SOIL EXCAVATED AT BUILDING SITE		Excavate & Place Shielding:	○	○	○	◑	◑	●	●		
	H	(Same as "D")								30%	70%
	I	(Same as "E")								60%	40%
	J	(Same as "F")								40%	60%
	K	(Same as "G")								80%	20%
EXPEDIENT SHELTERS 1. TRENCH TYPE	L	Excavate	◑	◑	◑	◑	◑	◑	◑	10%	90%
	M	Backfill	◑	◑	◑	◑	●	◑	●	50%	50%
2. ABOVE GROUND		Place Shielding:	○	○	○	◑	◑	◑	●		
	N	(Similar to "D")								30%	70%
	P	(Similar to "F")								40%	60%

Note: Portions of work performed by hand & equipment will vary. Values shown are approximate.

● Equipment is suitable for task
○ Equipment is not suitable
◑ Use if more suitable equipment is not available

Table 2

will make this decision based on conditions within his community. If an area is divided into zones or districts, a single borrow pit may serve two or more zones depending on lengths of haul and volume of material available in the pit.

Except when using a site source where the same equipment might be used for both digging and hauling, the shielding material will be hauled to the various structures in dump trucks. The number of trucks required depends on quantity of material to be handled, rate of production of the loading equipment and length of haul. It is likely that 5 to possibly 20 yard highway type trucks would be used. The larger trucks should be matched with the larger digging equipment. Although trucks will deliver material to different structures, an average haul distance between the source and structures can be used in determining production. Smaller trucks are more maneuverable in dumping material around the structure. Large trucks may not be able to get closer to the structure than the abutting street or driveway.

The operations of dig, load and haul are more or less independent of the placing operation. The shielding material would be delivered as fast as possible using available equipment. In some cases it may be found that time is sufficient to complete the dig and haul operation from one pit and then move the equipment to another. Since all material must be excavated and hauled the quantity is that as determined by the survey, say 60,000 cubic yards. An allowance for waste should be made, which, for purposes of this study is taken as 10%. Therefore

the quantity to be excavated and hauled is 66,000 cubic yards (1.1 x 60,000). These operations apply to Task Codes A, B and C of Table 2. If a site source is used, dig, load and haul operations would be included or allowed for with respect to placing Tasks H, I, J and K.

Where operating room is available, small bulldozers or front-end loaders would be used to place berm material. When machines are used to place berms care must be taken not to force the material against the walls in the process of placement. Material for roof shielding could be placed on the roof with a front-end loader (heights generally less than 12 feet), from boxes hoisted by a fork lift or by bucket brigades. Shielding of intermediate floors would be accomplished with the use of wheelbarrows, etc. Small "Bobcat" loader type equipment could be used on a flat roof if the structure would support the additional loading. Most structures however could not support such a load without substantial supplemental bracing of the roof. If the material has been dumped in one pile, an additional effort of moving it around the structure will be required.

It would not be practical to separately analyze the placing sequence required for each and every structure to be upgraded. Consequently, four placing situations are considered which would be typical of upgrading tasks in most host area communities. They are noted on Table 2 described as follows:

D. Single story, separate (at least 20 feet between buildings) structures where shelter spaces are at or above ground level. The requirement would be to place material in berms around the outside walls and on the roof. This task would also apply to multi-story buildings where shielding was placed on the first intermediate floor. It is assumed that the shielding material has been delivered to all sides of the structure.

E. The same conditions as Task D except that shelter spaces are located in a basement below ground level. The quantity of berm material would be less and the first floor shielded instead of the roof.

F and G. These tasks are similar to D and E respectively, except that structures are attached (wall to wall) as may be found in commercial areas. In this case, shielding material would probably be delivered to one side, requiring additional effort for placing even though the total length of wall berm per building would be less.

The task letters - D, E, etc. correspond to placing tasks shown on Table 2. If a site source were used, the dig and placing operations would be combined as shown for Tasks H, I, J, or K. It is apparent that many other situations could be described but the overall production to be achieved in placing shielding would be approximately the same in all cases.

The placing requirement is based on the general assumption of 1 cu yd per space (plus waste) which as mentioned could vary significantly depending on type of structure being upgraded. Although the effort per cubic yard would be about the same in

all instances, it would be helpful to make some distinction on the basis of type of shelter space or structure being upgraded. This would provide a better evaluation of the hauling requirement and more importantly, provide a better appraisal of actual amount of material to be delivered to each structure. These types of refinements could be made if time were available. To a certain extent the 10% waste factor will tend to offset quantity differences due to variations between actual and average shielding requirement.

A good percentage of the placing operations will be accomplished by hand labor; shovelling from stockpiles, pushing wheelbarrows, using bucket brigades and spreading material on roofs or floors. Since the placing operation is considered separately, the restrictions on equipment utilization due to dependency on hand labor are minimized in the overall upgrading process. An indication of manhours of labor for the placing operation as well as those required for other manual tasks is given in Section 2.

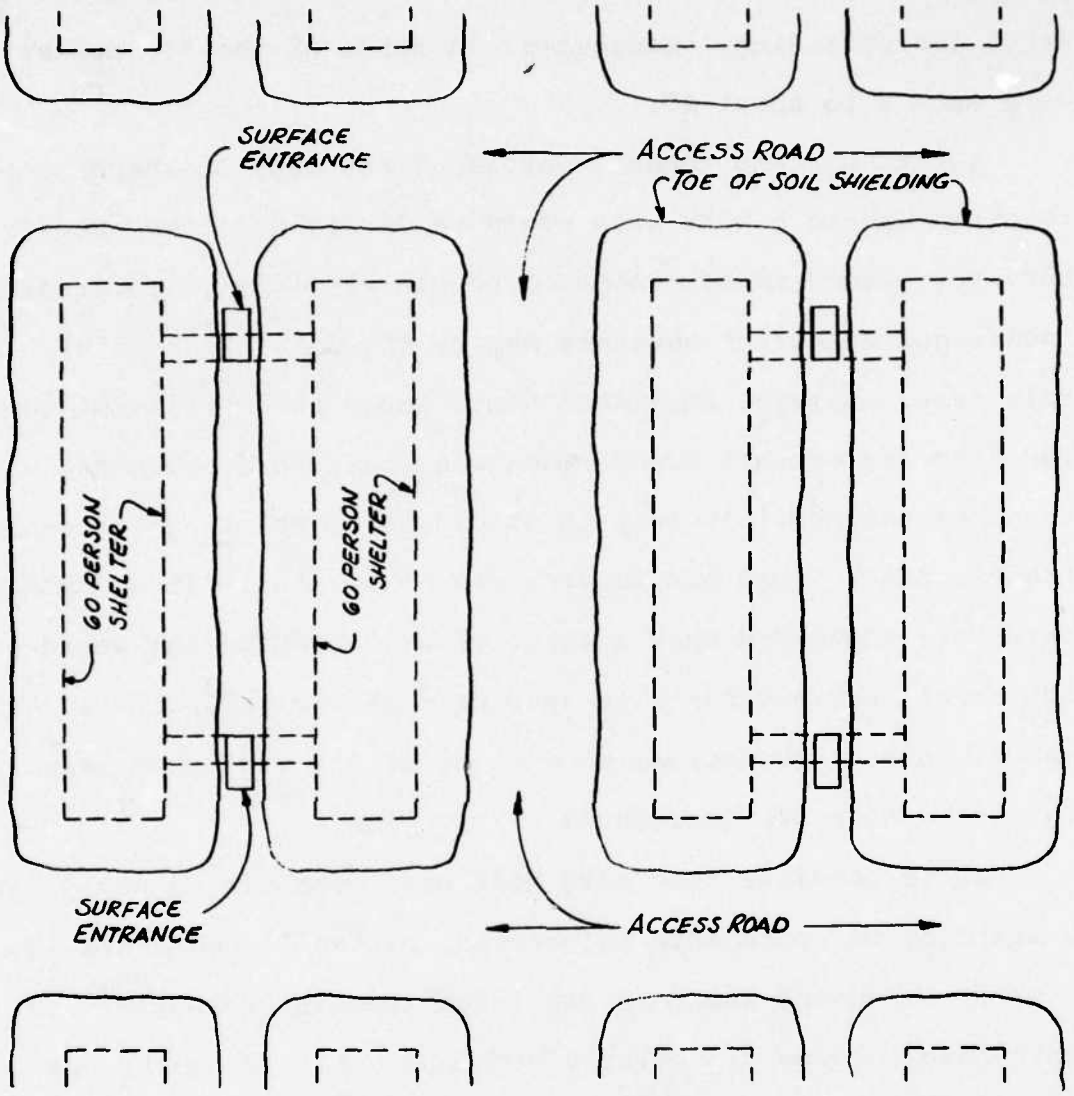
1.2.2 Expedient Shelters: Various studies and experiments (Reference 6) have shown that within the anticipated three day crisis build-up period, it would be possible for individual or groups of families to manually construct expedient type shelters affording protection factors of 200 or more. Reference 6 illustrates approximately fifteen shelters that could be made. Some consist of an open trench type of excavation which is eventually covered or provided with structural members supporting a shielded roof. Others are built above ground using a

structural frame (timber, logs, etc.) which is covered with earth for shielding. Capacities in terms of shelter spaces vary from 4 to about 60.

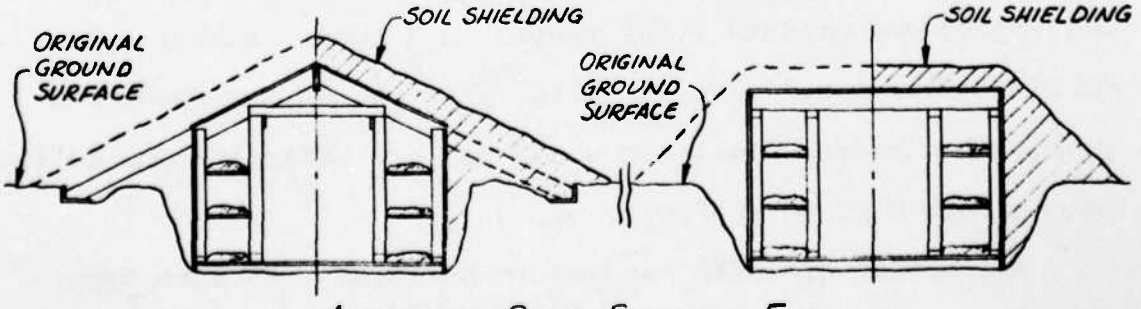
The number and location of expedient type shelters required within a host area would be determined from shelter surveys. Where small groups of people are fairly isolated, individual expedient shelters may be the only alternative. In this case, however, equipment usage would be inefficient compared to the overall need. Backhoes could be used to dig trenches and possibly help in shielding or erecting structural frames. Small front-end loaders may be helpful. If the shelters were scattered over a large area, the equipment would have to travel back and forth in keeping with the productivity of manual labor. The actual production of the equipment measured in cubic yards per hour would be very low.

It is possible that some host area communities would have a scarcity of upgradable structures, making it necessary to provide expedient shelters for large numbers of people. In this case, groups of shelters might be built in nearby open areas such as school yards, parking lots, football fields or parks. Figure 8 illustrates a trench type shelter arrangement that would accommodate 1,800 people in a school athletic field. Surface types could also be built. The use of equipment for groups of expedient shelters would be more effective due to the concentration of work effort.

The amount of earth handled in building a surface type expedient shelter is about 1.2 cu yd per space, and about 2 cu



COMMUNITY BUILT EXPEDIENT SHELTERS
IN LEVEL ATHLETIC FIELD



ALTERNATE CROSS SECTIONS FOR
SEMI-BURIED SHELTERS

Figure 8

yds per space for the trench type. A waste factor of 10% is added and in most instances the material is handled twice. The configuration shown on Figure 8 requires about 2 cu yds per space. This type of structure can be built at a depth where the soil excavated equals that needed for shielding. As noted previously, these shelters can afford higher protection factors than considered for upgradable structures.

Although equipment envisioned for host area tasks would be adaptable to digging trenches and placing backfill and shielding for expedient shelters there are certain obvious restrictions which must be considered. Trenches would not be dug in rock formations or where the water table is near the ground surface. Some earth formations, even when essentially dry, will not stand on vertical cuts without continuous bracing. Equipment will bog down in swampy or extremely wet areas. Structural frames would be constructed with manual labor, although some assistance may be had from equipment. If surface type shelters were built in a large paved parking lot or similar area, shielding material would probably be trucked in from a borrow pit, the same as considered for upgradable structures.

In assessing the utilization of equipment it is assumed that only groups of expedient shelters will be considered; either trench or surface types. The operations and tasks required for the trench shelters are designated as L and M on Table 2, those for surface shelters as Tasks N and P.

For trench shelters it is assumed that the excavated material will be sufficient for shielding, thereby eliminating the hauling operation. Trenches would be dug with backhoes or a combination of dozers and front-end loaders or by hand with hand tools and the material stock piled for subsequent use as shielding (Task L). The equipment would move to other trench excavations while the structural frame was erected in the completed trench. Shielding would then be placed using the equipment to the extent possible (Task M). Quantity of material is taken as 110% of the shelter space requirement or 2.2 cu yd per space.

Material to shield surface shelters would be obtained adjacent to the structure or from a borrow pit. In the first instance, material would be dug and placed with a backhoe, or possibly with dozers and front-end loaders (Task P). If a borrow pit is used, the dig-load-haul tasks would be similar to those of upgrading structures - A, B, and C; the placing task would be designated as "N". In both cases, the quantity of material would be about 1.3 cu yds per space.

Although the structural framing details used for expedient shelters have been minimized, pre-cutting or pre-fabrication would be very helpful. Since the quantity of timber and other building material is substantial, grouping shelters in specific locations will greatly facilitate the delivery of these items. In the event that a particular host area would require a large number of expedient type shelters, it is suggested that communities might want to consider construction of the shelters during periods of increased readiness.

1.2.3 Improving Facilities: This category of tasks is included primarily to indicate various miscellaneous uses of equipment which might be required within the host area. A large influx of people to a fairly small community could easily overtax existing water supplies, sanitation or other facilities. Tank trucks may be required to haul water, temporary outdoor sanitary facilities may have to be constructed. In areas of heavy snowfall, roads and streets must be cleared. Some congregate care facilities may need improvements requiring the use of equipment.

Most equipment needed for these tasks would be small, rubber-tired front-end loader-backhoe combinations and trucks with plows. Each planner would have to make his own evaluation of possible needs. For purposes of this study, it is assumed that two small equipment units are required for every 50,000 people within the host area (local plus evacuees).

1.3 HOST AREA EQUIPMENT REQUIREMENTS

Previous paragraphs have discussed various equipment needs for upgrading shelters and improving other host area capabilities during a crisis period. Required operations and tasks have been identified and an indication given as to approximate quantities of work involved.

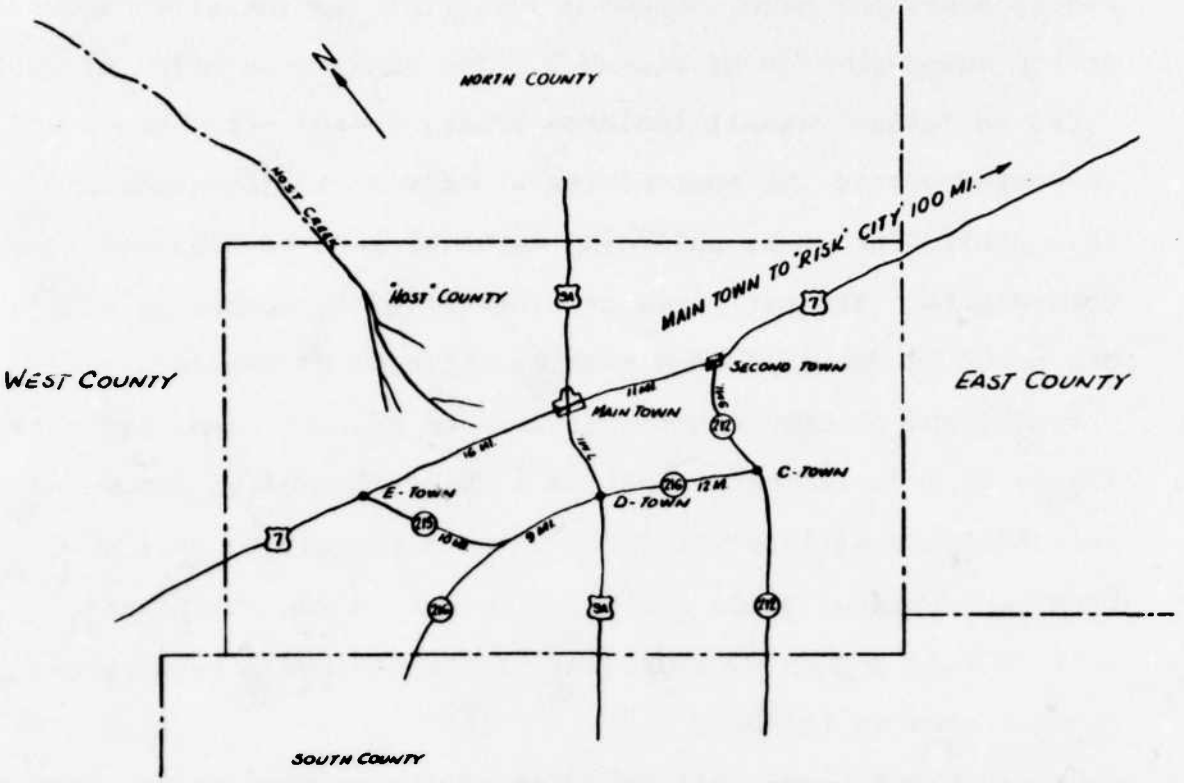
The major requirement relates to the handling of earth for shelter upgrading or construction. Quantities could be based on actual surveys or general assumptions of material required for shelter space plus an allowance for waste. In most cases, the material is handled twice. Exceptions would be where

material is obtained from a site source (adjacent to the structure) and is dug and placed in a single operation.

Although the use of equipment would be approximately the same in all host areas, it is apparent that specific details could vary significantly. Each planner will have to make evaluations of requirements for his particular area depending on its role in the overall CRP. Once requirements are defined -- type of task, quantity of work and location -- it will then be possible to make a determination of type and amount of equipment needed. Comparing this with equipment availability and productivity will enable the planner to finalize most effective utilization.

The overall process of determining equipment requirements would be made in general accordance with the following:

The host area would be defined either as a whole or by zones or districts which would be shown on a large scale map of the area. A sketch of a hypothetical host area is given on the top portion of Figure 9. In this case the host area includes several small communities having a total population of 20,000. CRP planning indicates that 40,000 relocatees must be accommodated. Based on surveys, the planner has determined that adequate congregate care facilities are available but there are no structures presently suitable for shelters. However, each community has various buildings which could be upgraded and which in total would provide 57,000 shelter spaces. This leaves a need for 3000 expedient shelter spaces which are assumed as trench types. A summary of congregate care and shelter



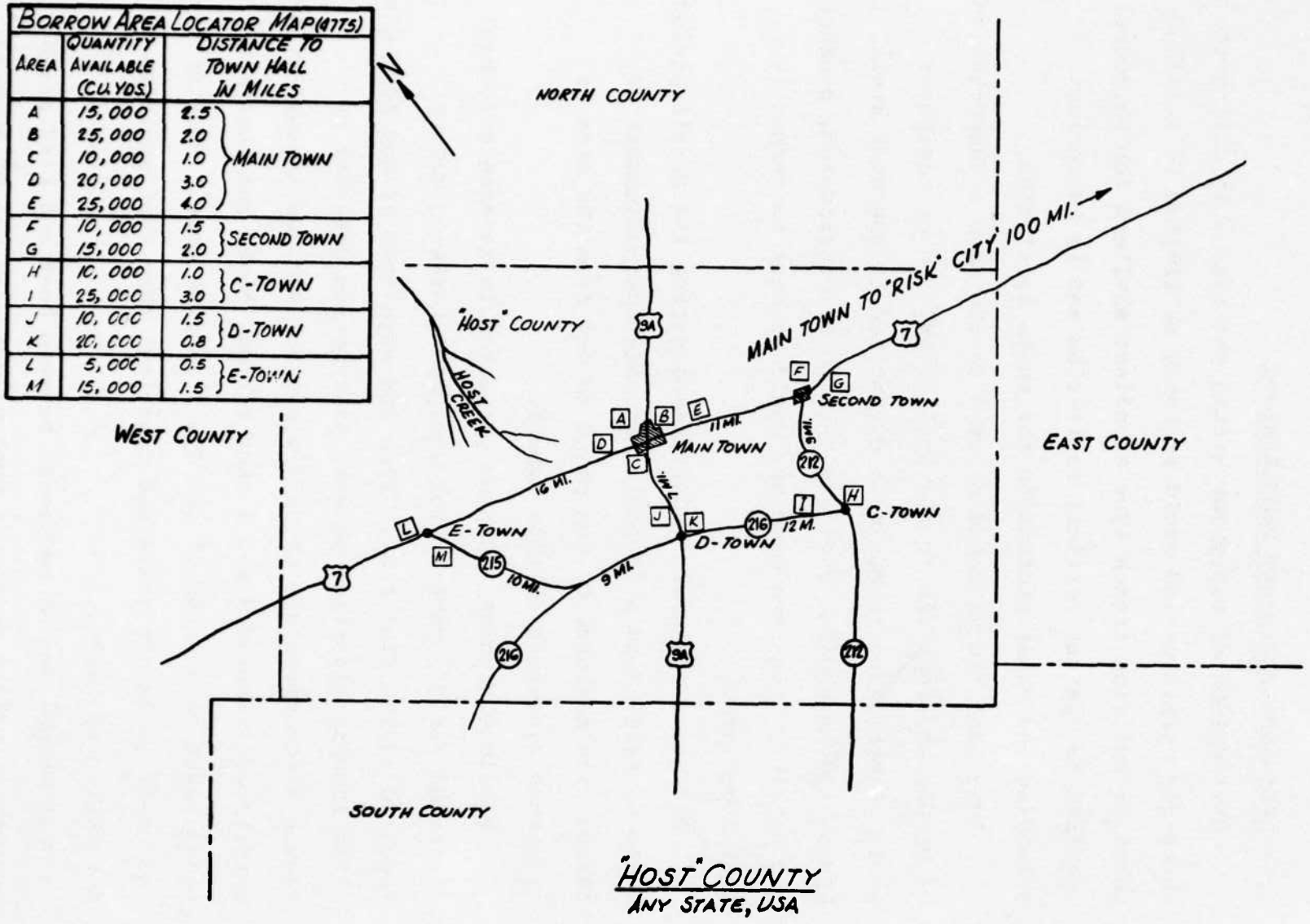
"HOST" COUNTY STATISTICS							
ITEM	COUNTY TOTAL	MAIN TOWN	SECOND TOWN	C TOWN	D TOWN	E TOWN	OTHER
NORMAL POPULATION	20,000	8,000	4,000	2,500	2,000	1,000	2,500
CONGREGATE CARE SPACES	43,000	25,000	10,000	4,000	3,000	1,000	-
UPGRADABLE SHELTER SPACES	57,000	30,000	14,000	6,000	5,000	2,000	-
SHELTER POPULATION:							
HOST COUNTY	20,000	8,500	4,500	3,000	2,500	1,500	-
RISK CITY	40,000	24,500	9,500	3,000	2,500	500	-
EXPEDIENT SHELTER SPACES REQUIRED	3,000	3,000	-	-	-	-	-

Figure 9

requirements for each community (districts or zones) is shown on the lower portion of Figure 9. The local population of 2500 shown as "other" (small isolated areas, farms, etc.) are relocated within the communities along with the evacuees. In this particular area, shielding material will be obtained from borrow pits. The pit sites are identified by number or code and noted on the map along with an estimate of available material and an approximate distance to nearest community - see Figure 10. On the basis that each shelter space in an upgradable building will require 1 cu yd of material and that each expedient shelter space will require 2.0 cu yds the planner is able to make a general appraisal of the equipment requirement for his area as follows:

1. Dig & Load: All material will come from borrow pits. Total quantity equals 69,300 cu yds.
   (57,000 x 1 + 3000 x 2.0) x 1.10 .
2. Hauling: Shielding material for each community will be obtained from the nearest borrow pit. Multiplying respective quantities by distances noted on Figure 10 gives a total hauling requirement of 83,160 cubic yard miles.
3. Placing: Sixty percent or 41,580 cy of material will be placed with equipment, the remainder by hand.

The above is a very general determination of host area equipment requirements for upgrading or providing shelter. A more detailed discussion is given in Section 4 which also describes how equipment would be utilized to accomplish the requirement.



"HOST" COUNTY
ANY STATE, USA

Figure 10

1.4 RISK AREA EQUIPMENT REQUIREMENTS

Utilization of equipment within the risk area during the three-day crisis period would probably be limited to isolated cases of building trench type expedient shelters for personnel required to operate critical facilities and in improving shielding and blast protection for those facilities.

Buses and trucks would be used in the mass transportation of people and supplies to the host areas. Other equipment would be mobilized in MSA's or dispatched to the host areas. If trench type expedient shelters were to be constructed, backhoes and possibly trenching machines would be sent to respective task locations.

Risk area equipment requirements during the crisis period would be related more to logistics than accomplishment of tasks. The movement of equipment to and from the area is discussed elsewhere in this report.

Previous studies, such as presented in Reference 7, have described various post attack equipment tasks as may be required in the risk area. Type and magnitude of one of these tasks (debris clearing) as well as type and quantity of required equipment can be determined for various assumed attack conditions. Tables 3 and 4 show typical tasks and equipment needs based on a study of the San Francisco area. Most of the equipment is larger (size and capacity) than that envisioned for host area tasks.

If mutual use of equipment between host and risk areas during the crisis period is contemplated, it can be assumed

SUMMARY - DEBRIS QUANTITIES
CITY OF SAN FRANCISCO
SIMULATED ATTACK #1

TASK NO.	QUANTITY OF DEBRIS (CU.YDS.) BY TYPE										TOTAL PER TASK CU. YDS.
	2-3	3-3	3-4	3-5	4-3	4-4	5-3	5-4	5-5	6-5	
1	1,090	7,050	6,975		7,105		7,985		59,390		89,595
2						29,060		85,710	24,855	100,430	240,055
3	1,925			20,635							22,560
4	5,125										5,125
5							9,820	12,680	18,355		40,855
6			10,350	6,710					3,350		20,410
7			4,140	27,855							31,955
8	7,370		7,400	4,520		4,095	22,160		19,995		65,540
9	11,375		5,900								17,275
10					1,610		2,655				4,265
11				8,630							8,630
12	2,220										2,220
TOTALS	29,105	7,050	34,765	68,350	8,715	33,155	42,620	98,390	125,945	100,430	548,525

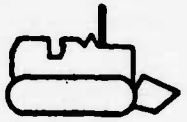
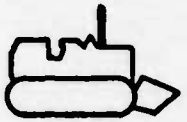
Note: Quantities and types reflect blast & fire conditions for all zones with situations of 7, 8 or 9. - Considers only main thoroughfares through city. For definition of debris types see Ref. 7.

Table 3

EQUIPMENT RESOURCE SUMMARY
TOTAL MACHINE HOUR FORECAST

ZONE OR TOTAL: San Francisco (Debris Clearing - Main Routes)

EQUIPMENT TYPE	CRANE	BULLDOZERS			
	CRAWLER	CRAWLER			
					
EQUIPMENT CODE	072	288	286	284	280
MACHINE HOURS	2953	1975	992	235	769

EQUIPMENT TYPE	LOADERS					
	FRONT END DUMP					SIDE DUMP
	WHEEL			CRAWLER		CRAWLER
						
EQUIPMENT CODE*	169	167	165	166	162	176
MACHINE HOURS	201	2264	2018	125	1551	309

*For definition of equipment codes see Table 5.

Table 4

that planning will be sufficient to define needs and to provide at least a general indication of equipment that could be deployed from one area to the other without impairing relocation or recovery efforts. Since it is likely that most equipment will be available in and around the risk area, it is apparent that pre-event planning and inventorying of risk area equipment will be vital to the CRP. Much of the equipment found in city, county or utility maintenance yards would be too small for effective use in debris clearing tasks of the post-attack period; therefore it could be deployed initially to host area locations. Dump trucks of 5 - 10 yard capacity would also be more adaptable to host area tasks. Larger equipment would be mobilized at the risk area MSA's.

1.5 SUMMARY

Most CRP equipment requirements within the host area can be fairly well defined on basis of previous studies and surveys. To the extent possible, tasks should be planned and scheduled so as to concentrate the equipment resources on relatively high production operations such as digging, loading and hauling from a common borrow pit. Equipment usage should not be geared to the actual placing of shielding material, which to a large extent is dependent on manual labor. The use of additional equipment if available, will speed up placing tasks. Detailed information regarding sources of suitable shielding material should be provided. All quantities, whether determined by use of average requirement or from actual calculations, should be increased by 10% to allow for waste. If a

large number of expedient type shelters is required, they should be grouped in specific areas. Small isolated expedient shelters should be constructed with manual labor.

Risk area requirements during or after the crisis period would have to be determined from specific planning details for the area. Expedient type shelters or other protective work which might be accomplished during the crisis period must be capable of withstanding blast and heat effects of an attack.

Effective use of risk area equipment within the host area (or vice versa) must be pre-planned. Any large scale movement of equipment between the two areas should be accomplished prior to start of the relocation period.

Using equipment to provide adequate shelter for possibly hundreds of thousands of people is a major undertaking. The planner must make preliminary plans, layouts and schedules of all operations well in advance of the crisis period if the tasks are to be accomplished in an efficient manner.

SECTION 2

EQUIPMENT

CLASSIFICATION, OPERATION & PRODUCTION

2.1 GENERAL

In planning the utilization of equipment it is necessary to know both the task for which it is to be used and its operating requirements and production. CRP tasks have been discussed in Section 1. This section defines various operating characteristics of equipment most likely to be used during the crisis period. All equipment is considered as standard makes or models commonly used in the construction industry.

Primary use of equipment during the crisis period would be in performing host area tasks of upgrading or building shelter facilities. Similar tasks may be required in the risk area but for purposes of this study they are considered incidental to the overall need. However, consideration should be given to the fact that equipment must be available for emergency use within the risk area if an attack should occur. Possible utilization and transfer of equipment between risk and host area locations due to this requirement is discussed elsewhere in the report.

Host area tasks can be accomplished with smaller units of equipment than generally visualized for emergency tasks (early post-attack period) within the risk area. To a degree, this tends to facilitate the problem of mutual utilization, i.e. certain units of equipment would not be considered for transfer between areas. An indication of the adaptability of equipment for either host or risk area tasks is given in paragraph 2.2.

Equipment needed during the crisis period would be front-end loaders, bulldozers, backhoes, shovels and dump trucks. Cranes and forklifts could be used for certain tasks such as erecting frames for expedient shelters or lifting shielding material to roofs of structures. Small garden type tractors or similar equipment would be used if available but for purposes of this study are not classified as equipment.

Various makes, models and sizes of different types of equipment would be available in both areas. Most equipment will probably be found in or near the risk area at locations such as maintenance and contractors' yards, construction projects, quarries or gravel pits, equipment dealers and material supply or rental firms. Equipment within the host areas would be found in similar locations plus farms and possibly mines.

In order to take inventory and to allocate available equipment to specific tasks and areas, it is necessary to have a convenient method of identification which could be used in all instances. A suggested classification is discussed in the next paragraph.

2.2 CLASSIFICATION OF EQUIPMENT

Previous reports, such as "Plan Bulldozer" (Reference 8) have classified different makes and models of all equipment by code in accordance with general characteristics such as horsepower ratings, production capacity and whether track-mounted or rubber-tired. A similar classification was used to identify equipment and servicing vehicles for debris clearing operations (Reference 7 and 9). Although the equipment needed during the

crisis period would be of the same general type, CRP tasks are such that a greater variety (less horsepower, smaller capacities, etc.) could be effectively used. Since all equipment must be considered, the classification for debris clearing has been expanded to include units suitable for CRP tasks. This classification is shown on Table 5. Subsequent reference to a particular unit of equipment will be by use of the applicable code number. For instance, a 100 HP rubber-tired front-end loader would be indicated by code 161B. Dozers and loaders under 100 HP would not be effective for debris clearing therefore would be considered only for host area tasks. Large dozers and loaders, scrapers, graders and clamshells are not suitable for upgrading tasks but could be used in the risk area. This helps in the initial planning of equipment transfer between host and risk areas. It is obvious, however, that if there was a scarcity of equipment in the host area, large equipment would not be deployed to the risk area, or vice versa with respect to small units in the risk area. If significant units of equipment not identified on Table 5 were found in either area, the table should be expanded with new codes assigned accordingly.

2.3 EQUIPMENT OPERATING REQUIREMENTS

Equipment operation implies the use of various other resource requirements such as labor, fuel, lube and supplies. These requirements are usually given in units per hour based on actual operating time. Table 6 shows requirements for all equipment listed on Table 5. The type of equipment is noted in the left hand column followed by the equipment code designa-

CLASSIFICATION OF EQUIPMENT - CODE NUMBERS

HORSEPOWER RATING OR CAPACITY	BULLDOZERS		FRONT-END LOADERS				MOTOR GRADERS	SHOVELS		CLAMSHELLS		BACKHOES		SCRAPERS		CRANES		TRUCKS
			End-Dump		Side-Dump													
	Crawl	Wheel	Crawl	Wheel	Crawl	Wheel	Wheel	Crawl	Wheel	Crawl	Wheel	Crawl	Wheel	Self-Propel	Self-Load	Crawl	Wheel	Wheel
50 to 75 HP	280A		160A	161A														
75 to 100 HP	280B		160B	161B														
100 to 125 HP	280C		160C	161C														
125 to 150 HP	280D		160D	161D														
Up to 150 HP					170	171	141											
150 to 200 HP	282	283	162	163	172	173	143											
200 to 250 HP	284	285	164	165	174	175	145											
250 to 300 HP	286	287	166	167	176	177												
Over 300 HP	288	289		169		179												
Up to 1 cu yd								260	261	080	081	020	021					
1 to 1½ cu yd								262		082	083							
1½ to 2 cu yd								264		084	085							
2 to 3 cu yd								266		086	087							
1 to 2 cu yd												022	023					
2 to 3 cu yd												024	025					
3 to 10 cu yd								268		088	089			251	255			311
10 to 15 cu yd														253	257			313
15 to 20 cu yd																		315
Up to 11 tons																070	071	
11 to 20 tons																072	073	
Over 20 tons																074	075	
Low Bed Truck																		317
Service Truck																		751
Tire Truck																		753
P.O.L. Truck																		755

Table 5

EQUIPMENT OPERATING REQUIREMENTS								
EQUIPMENT		P.O.L. REQ/HR				LABOR/HR		
TYPE/MOUNT	CODE	GAS GAL	DIES GAL	LUBE LB	OIL GAL	GRADE		
						1	2	3
DOZERS								
Crawler	280A	-	2.8	.2	.08	1	.14	-
	280B	-	3.6	.2	.10	1	.16	-
	280C	-	4.4	.3	.12	1	.18	
	280D	-	5.0	.4	.14	1	.20	-
	282	-	8.0	.4	.17	1	.25	-
	284	-	11.3	.5	.24	1	.30	
	286	-	14.1	.7	.27	1	.33	-
	288	-	16.6	.8	.40	1	.41	-
Wheel	283	-	7.5	.3	.17	1	.23	-
	285	-	10.0	.4	.20	1	.25	-
	287	-	13.7	.7	.30	1	.35	-
	289	-	17.5	.7	.44	1	.47	-
F.E. LOADERS								
End Dump Crawler	160A	-	2.8	.3	.05	1	.16	-
	160B	-	3.6	.3	.07	1	.18	-
	160C	-	4.4	.4	.09	1	.20	-
	160D	-	5.0	.5	.11	1	.22	-
	162	-	7.5	.6	.16	1	.31	-
	164	-	10.0	.7	.21	1	.35	-
	166	-	11.5	.9	.25	1	.37	-
Wheel	161A	-	3.0	.2	.07	1	.18	-
	161B	-	4.0	.2	.09	1	.20	-
	161C	-	4.8	.3	.11	1	.22	-
	161D	-	5.6	.3	.13	1	.24	-
	163	-	8.1	.6	.17	1	.37	-
	165	-	10.5	.7	.22	1	.40	-
	167	-	13.5	.8	.30	1	.42	-
	169	-	15.1	.8	.35	1	.46	-
Side Dump Crawler	170	-	5.0	.5	.11	1	.24	-
	172	-	7.5	.7	.17	1	.34	-
	174	-	10.0	.7	.21	1	.36	-
	176	-	11.5	.9	.25	1	.40	-
Wheel	171	-	5.2	.4	.11	1	.26	-
	173	-	8.0	.6	.17	1	.40	-
	175	-	10.7	.7	.22	1	.39	-
	177	-	13.7	.8	.31	1	.45	-
	179	-	14.5	.8	.33	1	.47	-

Table 6

EQUIPMENT OPERATING REQUIREMENTS								
EQUIPMENT		P.O.L. REQ/HR				LABOR/HR		
TYPE/MOUNT	CODE	GAS GAL	DIES GAL	LUBE LB	OIL GAL	GRADE		
						1	2	3
GRADERS								
Wheel	141	-	5.8	.3	.13	1	.23	-
	143	-	7.3	.3	.17	1	.25	-
	145	-	10.0	.4	.22	1	.28	-
SHOVEL								
Crawler	260	-	3.7	.8	.08	1	.29	-
	262	-	7.0	1.0	.15	1	.32	-
	264	-	9.5	1.2	.20	1	.38	-
	266	-	10.3	1.5	.20	1	.45	-
	268	-	10.8	1.8	.23	1	.60	-
Wheel	261	3.0	4.0	.8	.20	1	.30	-
BACKHOES								
	020	-	4.0	1.0	.12	1	.30	-
	022	-	6.0	1.3	.20	1	.35	-
	024	-	11.0	2.0	.30	1	.45	-
CRANES								
Crawler	070	-	4.0	.7	.09	1	.32	-
	072	-	6.0	.8	.10	1	.38	-
	074	-	9.0	1.1	.14	1	.52	-
Wheel	071	-	6.5	.5	.18	1	.33	-
	073	8.0	-	.3	.10	1	.35	1
	075	8.0	3.1	.9	.20	1	.50	1
TRUCKS								
Dump 5 cu yd	311	5.0	-	.10	.03	-	.15	1
10 cu yd	313	-	6.0	.12	.04	-	.18	1
20 cu yd	315	-	7.0	.14	.05	-	.20	1
Flat Bed Truck	317	4.5	4.5	.35	.21	-	.16	1
Service Truck	751	2.0	-	.04	.02	-	.10	1
Tire Truck	753	2.0	-	.04	.02	-	.10	1
P.O.L. Truck	755	2.0	-	.06	.03	-	.10	1
Sweeper	757	2.0	2.0	.15	.08	-	.15	1
Air Compressor	600	-	3.0	.20	.07	-	-	-
Light Plant	602	0.8	-	.01	.01	-	-	-

Table 6 (Continued)

tion. P.O.L. (petroleum, oil and lubrication) requirements are listed next. Fuel is shown as either gasoline or diesel in gallons per hour. Lubrication is noted in pounds and oil in gallons. Three classes of labor are shown: 1) operator, 2) mechanics-general maintenance and servicing and 3) semi-skilled including drivers.

To complete crisis period tasks within 3 days it will be necessary to have an adequate pool of qualified operators, drivers and other labor. Time will not permit special training. Under normal circumstances there would be as many, if not more, equipment operating personnel within an area than there are units of equipment. During the crisis period however, units will probably be worked around the clock thereby requiring at least 2 and possibly 3 operators per unit. This may require the need for bringing in outside personnel; a pre-event planning problem. Other labor such as flagmen and dumpmen, as well as manual laborers for placing shielding material will also be required. These needs are discussed in paragraph 2.6. Supervisory personnel is discussed in Section 3.

No requirement is shown for repair parts or tires as it is assumed that all equipment will be in good working condition at start of the 3-day crisis period. Any equipment requiring major repair or overhaul would not be considered.

In subsequent parts of this report, methods and procedures for determining number of equipment hours to complete a task are discussed. This is obtained by dividing total quantity of work by the hourly production of the equipment. Knowing the equip-

ment hours it is then possible to determine total operating requirements. For instance, if a rubber-tired, front-end loader - code 161D - were used for 50 hours to complete a task, the requirements would be:

Code 161D	50.0 hours
Labor-Operator (1)	50.0 hours
Mechanic (2)	12.0 hours
Diesel Fuel	280.0 gallons
Lube	15.0 lbs
Oil	6.5 gallons

During the crisis period there will be a fair amount of time spent for mobilization or moving between tasks during which the equipment is used but not producing. Although this lost time or operating efficiency could vary significantly, for purposes of this study a factor of 20% is used. Therefore, the 50 hours as noted above would be increased to 60 (50 x 1.20) in determining both operating requirements and equipment hours for the particular task.

2.4 EQUIPMENT PRODUCTION

Major use of equipment during the crisis period will be for completing host area tasks of upgrading structures and building expedient shelters. Both can be considered as earth moving tasks where equipment production is considered in units of cubic yards per hour. However, even when using the same unit of equipment this production varies depending on type of operation and material being handled. These operations, as discussed in Section 1, are:

1. Dig and Load: This applies primarily to a borrow pit operation although a site source adjacent to a structure could be used. When considering trench type expedient shelters, the operation will consist of digging the trench and placing material in stockpiles.
2. Hauling: Material from borrow pits will be hauled in dump trucks to various upgradable structures and possibly surface type expedient shelters. If a site source is used, the hauling might be accomplished with the digging equipment.
3. Placing: Equipment will place about 60% of the shielding material around or on a structure, and will probably be used in conjunction with hand labor in placing the remaining 40%. Different operations, conditions and tasks are noted by code on Table 2.

The material to be handled is earth, with the only distinction being whether it's hard or soft. This affects primarily the digging operation.

In subsequent discussions, measures of production -- cubic yards per hour etc. -- reflect average conditions which could reasonably be anticipated for crisis period tasks. They consider various elements such as cycle times for shovels or loaders, haul speeds for trucks and 50 minute working hours. In some areas, conditions may be such that greater production could be achieved, in others, a lower production rate. Allowances could be made by the planner depending on his appraisal of conditions within the area. Under normal conditions, however,

production rates would probably not vary by more than plus or minus 10% from the average. An obvious exception would be where severe weather conditions made the use of equipment marginal.

The intent is to provide the planner with guidelines by which realistic estimates of equipment production and requirements can be made. These requirements can be expressed in total hours for different types of equipment or as the actual number of equipment units required. For instance, if it has been determined that 3,000, 5-yard truck hours are needed and that the work is to be accomplished in 60 hours, it will be necessary to use 50 trucks. As mentioned in paragraph 2.3, equipment time determined by dividing quantity of work by average hourly production should be increased by 20% to allow for lost time and other inefficiencies when considering equipment operating requirements.

It would not be possible to show production rates for all potential situations, consequently the planner may have to make an adjustment of hourly production by interpreting or averaging different rates given herein. This may be the case where it is necessary to use a unit of equipment not particularly suited for a task.

2.4.1 Dig and Load: Two sources of material are considered, either from a borrow pit or site source adjacent to the structure. Borrow pits would probably involve a large quantity of material, which offers a wider choice of equipment usage. Shovels would be impractical to handle small quantities in different locations but could be used in a borrow pit even

though the depth of cut may not be optimum. This unit would dig and load in a single operation. Backhoes could be used in a similar fashion. Most earth type materials can be dug with front-end loaders. If available, bulldozers with rippers could loosen hard material, thereby improving production or they could be used to doze material into stock piles to be loaded into trucks with front-end loaders. Working with stock-piled material greatly increases loader production.

Although all sizes and types of bulldozers, front-end loaders, shovels and backhoes listed on Table 5 can be used for borrow pit operations the planner will have to make practical decisions of appropriate combinations depending on quantity of material to be dug and size of hauling units. For instance, a one cubic yard backhoe (Code 020) would not be used to load 20 yard trucks, nor would a 5 yard shovel (Code 268) be moved to a pit where only 1,000 cubic yards had to be dug.

Table 7 shows average hourly production (cu yds/hr) to be obtained by different equipment units most likely to be used for the dig-load operation from a borrow pit (Tasks A & B). If a combination of bulldozers and front-end loaders was used, the two lower tabulations would be considered together; matching the appropriate dozing and loading capacities. In subsequent discussions of the hauling operation (Task C) reference is made to a loading rate in determining number of trucks required. This rate represents the total production from the pit which could reflect one or a combination of several units of dig-load equipment. If a loading rate of 200 cu yds/hr was considered, a

EXCAVATING AND LOADING TRUCKS AT BORROW AREA PRODUCTION RATES (CU.YD./HR.)						
SINGLE UNIT OPERATION (TASKS A & B)						
EQUIPMENT CODE	BACKHOE			SHOVEL		
	020	022	024	260	262	264
SOFT EARTH	70	140	190	80	160	220
HARD EARTH	55	110	150	60	130	180
MULTIPLE UNIT OPERATIONS						
EXCAVATING (TASK A)						
EQUIPMENT CODE	BULLDOZER					
	280C	280D	282	284	286	288
SOFT EARTH	110	140	230	330	400	520
HARD EARTH	85	110	180	260	320	420
LOADING (TASK B)						
SINGLE LOADER		160D	162 & LARGER	161D	163 & LARGER	
		100	140	130	185	
TWO LOADERS	160D	200	240	230	285	
	162	-	280	270	325	
	161D	-	-	260	315	
	163	-	-	-	370	

Note: Use combinations of available dozer/loader(s) to achieve maximum efficiency. Combined production is lesser of two numbers, i.e. combined rate for 1-284 dozer (hard earth) 1-161D loader & 1-162 loader is 260 cu yd/hr. Usually more than one team can work at same borrow area.

Table 7

combination of one 282 bulldozer and two 160D front-end loaders or a single 264 shovel would meet the requirement. Smaller units would be more adaptable where material is obtained from a site source and in some instances could also be used for the placing task. Table 8 lists estimated dig and load hourly production rates for bulldozers, front-end loaders and combination backhoe - loader units. The upper portion of the table lists units which would probably be used at a site source. Some of the larger units listed in the lower portion of the table are the same as shown on Table 7.

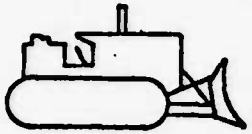
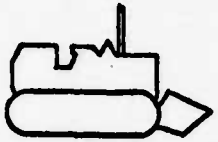
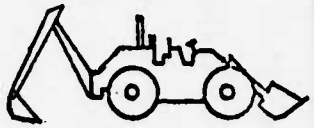
In addition to hourly production rates, the dig-load operation can be considered on the basis of the number of cubic yards handled within a certain period of time. Table 9 shows various equipment units which would dig and load given quantities of material within a 3 day period. Similar tables could be prepared using the production rates shown on Tables 7 or 8.

The planner has a larger leeway in selecting equipment for digging and loading than for other host area operations. His choice will relate primarily to the proper sizing and matching of equipment keeping in mind that this operation has the greatest potential for high production performance. Knowing the conditions within his area and possibly in conferring with local earth moving contractors, the planner should soon have a good feel in matching equipment with specific production requirements.

Some preliminary investigation and planning will be required in the selection of borrow pits. A planned source where rock or ground water is encountered two feet below the

EQUIPMENT CODES AND STANDARD PRODUCTION RATES

BULLDOZERS AND FRONT END LOADERS

TYPE	BULLDOZERS		FRONT END LOADERS				
	CRAWLER*		CRAWLER		WHEELED		W/BACKHOE
							
HORSEPOWER RATING	CODE NUMBER	STD. PROD. CU. YD/HR	CODE NUMBER	STD. PROD. CU. YD/HR	CODE NUMBER	STD. PROD. - CU. YD/HR LOADER	BACKHOE
50 to 75	280A	60	160A	30	161A	40	10
75 to 100	280B	80	160B	55	161B	70	15
100 to 125	280C	110	160C	75	161C	100	20
125 to 150	280D	140	160D	100	161D	130	25
150 to 200	282	230	162	140	163	185	-
200 to 250	284	330	164	185	165	250	-
250 to 300	286	400	166	245	167	330	-
Over 300	288	520	-	-	169	430	-

*For purposes of this study wheeled dozers are considered equivalent of crawler dozers.

Table 8

EQUIPMENT REQUIREMENTS FOR EXCAVATION AND LOADING TRUCKS AT SHIELDING SOIL SOURCE (TOTAL EXCAVATION FOR 3 DAY PERIOD)			
TOTAL QUAN.(CY) REQUIRED IN 3 DAYS	ALTERNATE EQUIPMENT*		
	SHOVEL	BACKHOE	DOZER & LOADER TEAMS
To 3,000	1 - 260	1 - 020	1 - 280A & 1 - 160B
3,000 - 4,000	1 - 260	1 - 020	1 - 280B & 1 - 160C
4,000 - 5,000	1 - 262	1 - 022	1 - 280B & 1 - 160D
5,000 - 6,000	1 - 262	1 - 022	1 - 280C & 1 - 160D
6,000 - 8,000	1 - 262	1 - 022	1 - 280D & 1 - 162
8,000 - 10,000	1 - 264	1 - 024	1 - 282 & 2 - 160D
10,000 - 15,000	1 - 264 & 1 - 260	1 - 024 & 1 - 020	1 - 284 & 2 - 162

*Under each category shown wheel or crawler equipment can be used.

Larger equipment than that shown can be used if available, but without increase in production, which is limited by truck size & loading considerations.

Table 9

surface could prove embarrassing. Suitable ramps in and out of the pit must be provided as the depth of cut increases. Preliminary preparations such as clearing or building access roads should be completed before the start of the crisis period.

2.4.2 Hauling: This study assumes that most shielding material is obtained from borrow pits and hauled in dump trucks to various structures within the area. If physical features and configuration of a particular area are such that material could be obtained adjacent to the structure, then this operation C would not be required for that particular task.

The rate of hauling material depends on 1) the production of the dig-load equipment, 2) the size of the truck and 3) the length of haul. Although in actual practice the haul would also be defined in terms of road surfaces and grades, no allowance is made in this study except that truck speeds used could be considered average for most conditions likely to be encountered. It is also assumed that a reasonable match between number of trucks and loading equipment is obtained, i.e., too many trucks would result in excessive waiting time at the pit; if too few, the loading equipment would be idle.

Matching dig and load equipment with number of trucks required could be made in several ways. If time was available, equipment managers or planners could make calculations for optimum operation. However, the overall average requirement could be readily made by using one of the following procedures:

1. One measure of the hauling requirement is cubic yard miles. (Total quantity times average haul distance.)

Units of "cubic yard miles" produced by different sized trucks for several loading rates and average lengths of haul are shown on Figure 11. Assuming an average haul distance of 2 miles, a loading rate of 400 cu yds per hour and using 20 yard trucks, the production per truck would be about 107 cubic yard miles per hour. If the total requirement was 15,000 yard-miles it would require 140 truck hours to complete. In an actual situation, the haul distance would be determined by scaling distances between the pit and structures on a large scale map of the area. The loading rate and size of truck would also reflect the actual situation.

2. Another measure of the hauling requirement could be given in total cubic yards hauled per hour with respect to type of equipment used (both dig and haul) and length of haul. Figure 12 shows this relationship. Assuming that 500 cu yds per hour must be delivered from the borrow pit, a loading rate of 200 cu yds per hour and a haul distance of one mile, the task would need 23-5 yard trucks, 13-10 yard trucks or 8-20 yard trucks.

3. The hauling requirement can also be determined on the basis of cubic yards hauled per truck per hour on the basis of size, length of haul and loading rate. Referring to Figure 13 and assuming a 1.5 mile haul with a loading rate of 100 cu yds per hour, a 5 yard truck would haul approximately 16 cu yds per hour, a 10 yard

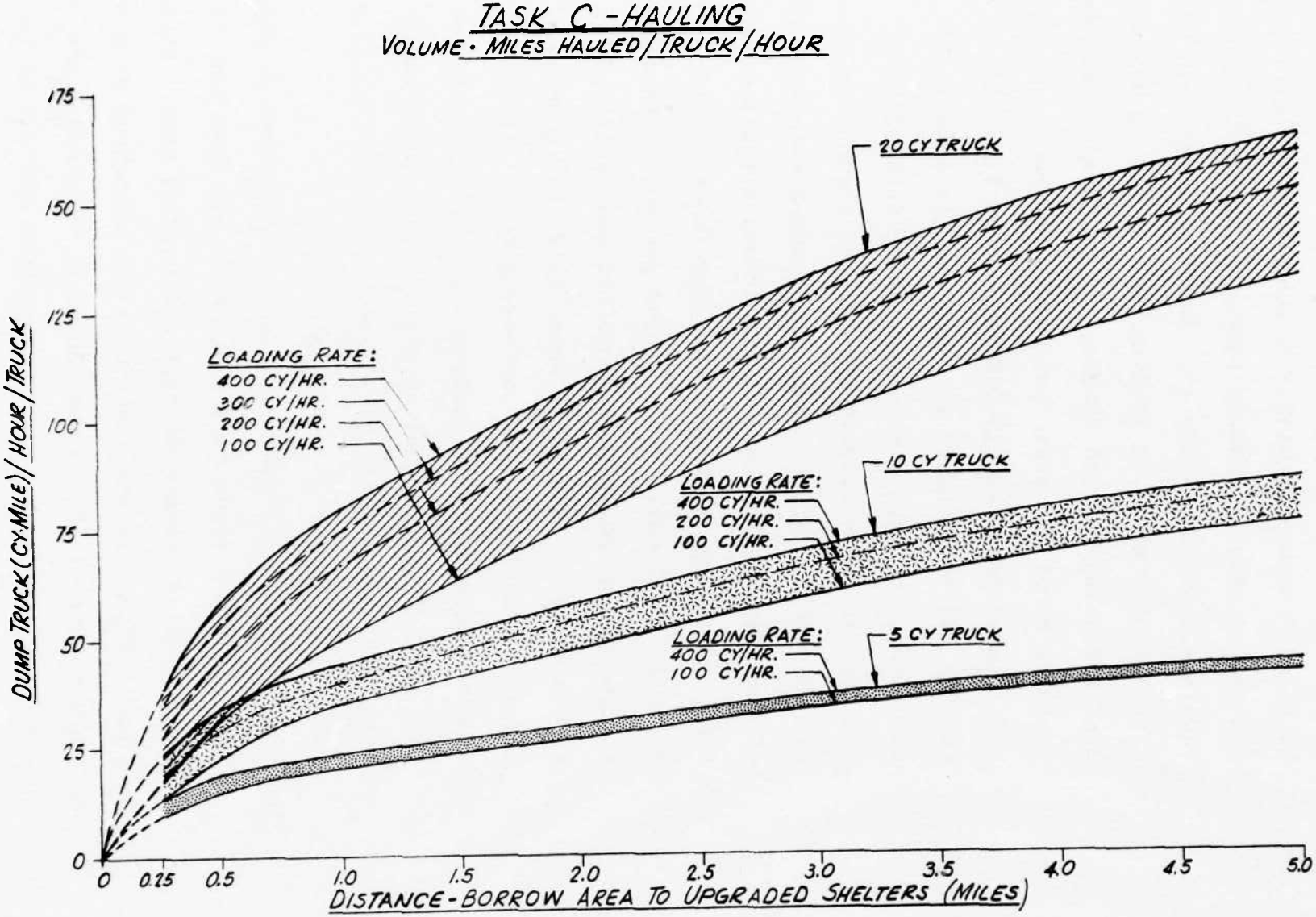

TASK C - HAULING
VOLUME · MILES HAULED / TRUCK / HOUR
DUMP TRUCK (CY-MILE) / HOUR / TRUCK
175
150
125
100
75
50
25
0
20 CY TRUCK
LOADING RATE:
400 CY/HR.
300 CY/HR.
200 CY/HR.
100 CY/HR.
10 CY TRUCK
LOADING RATE:
400 CY/HR.
200 CY/HR.
100 CY/HR.
5 CY TRUCK
LOADING RATE:
400 CY/HR.
100 CY/HR.
0
0.25
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
DISTANCE - BORROW AREA TO UPGRADED SHELTERS (MILES)

Figure 11

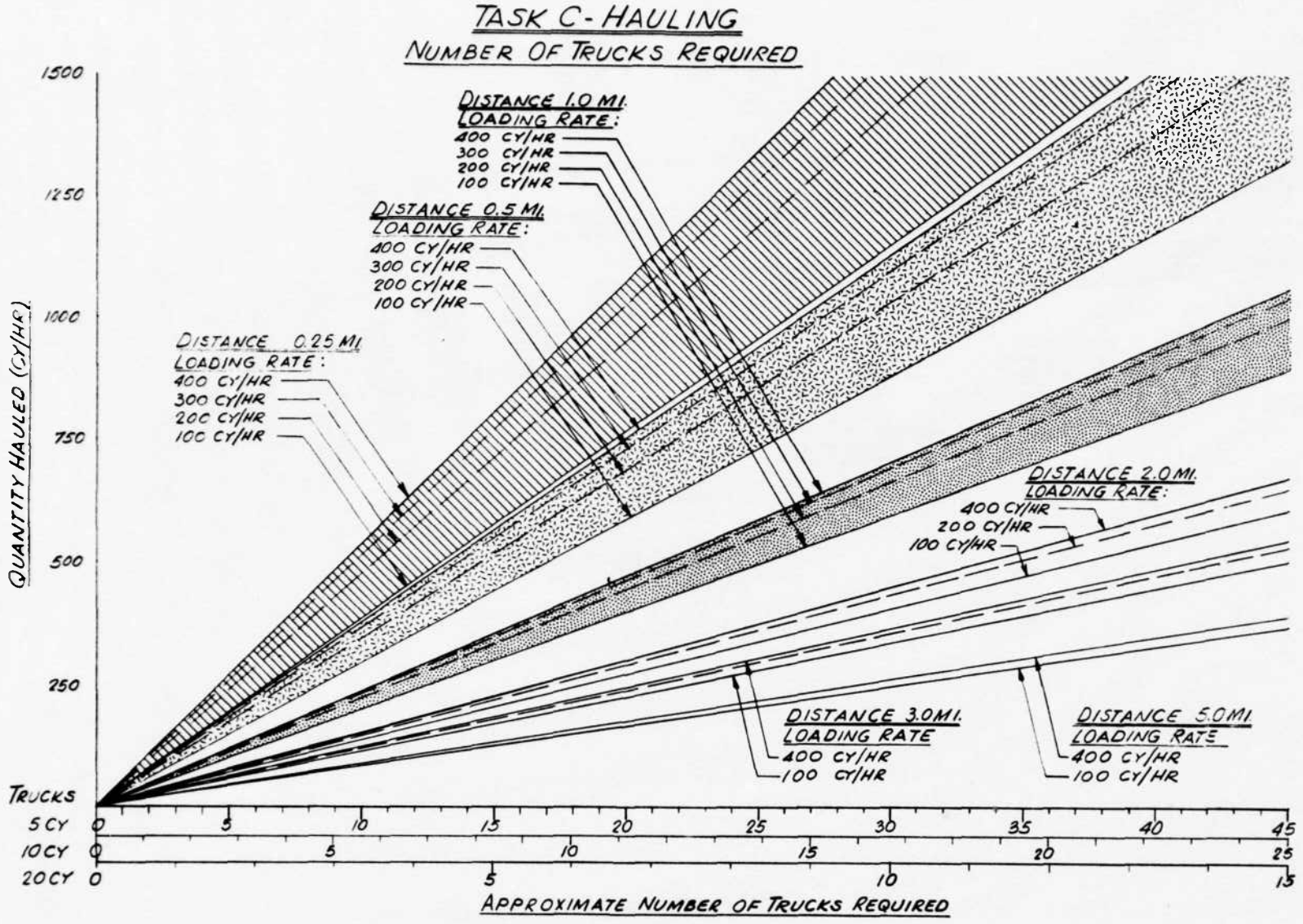

TASK C - HAULING
NUMBER OF TRUCKS REQUIRED
QUANTITY HAULED (CY/HR)
1500
1250
1000
750
500
250
DISTANCE 1.0 MI.
LOADING RATE:
400 CY/HR
300 CY/HR
200 CY/HR
100 CY/HR
DISTANCE 0.5 MI.
LOADING RATE:
400 CY/HR
300 CY/HR
200 CY/HR
100 CY/HR
DISTANCE 0.25 MI.
LOADING RATE:
400 CY/HR
300 CY/HR
200 CY/HR
100 CY/HR
DISTANCE 2.0 MI.
LOADING RATE:
400 CY/HR
200 CY/HR
100 CY/HR
DISTANCE 3.0 MI.
LOADING RATE
400 CY/HR
100 CY/HR
DISTANCE 5.0 MI.
LOADING RATE
400 CY/HR
100 CY/HR
TRUCKS
5 CY 0 5 10 15 20 25 30 35 40 45
10 CY 0 5 10 15 20 25
20 CY 0 5 10 15
APPROXIMATE NUMBER OF TRUCKS REQUIRED

Figure 12

TASK C - HAULING
VOLUME HAULED/TRUCK/HOUR

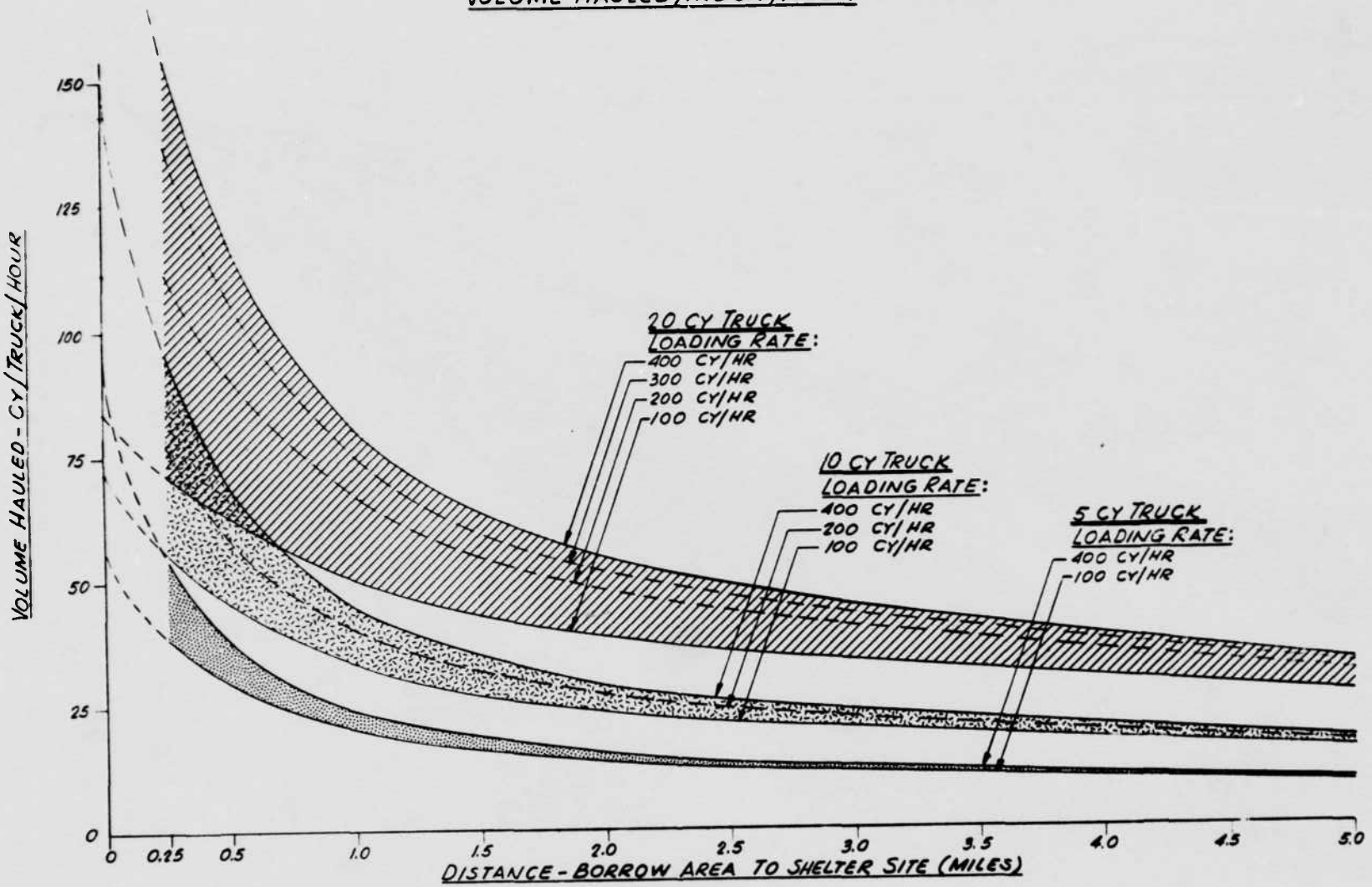


Figure 13

truck - 30 cu yds per hour and a 20 yard truck about 43 cu yds per hour.

In all cases, the loading rate is such as to minimize wait time in the pit and could reflect the use of several different dig and load units as discussed in paragraph 2.4.1.

Although truck hauling appears to be fairly straightforward, there are many conditions to be considered which could make the difference between a successful or unsuccessful operation. Unless the borrow pit abuts an existing street or road, it will be necessary to construct an access road from the pit. Preliminary plans for haul routes to and through the community should be laid out. It may be necessary to place barricades, etc. so as to prevent other traffic from using the routes during the hauling period. Trucks tied up in a traffic jam are useless. Flagmen must be provided along the routes to direct trucks to specific structures. If different sized trucks are being used, the smaller ones should be routed to structures where turning or dumping space may be limited. If material is being delivered before the placing crew arrives, a dump man will be needed. In some instances, it may be necessary to use water trucks or other equipment to maintain safe hauling conditions. Fuel and service trucks will be required. While not directly related to equipment production it is apparent that proper planning and coordination of these and other conditions will be crucial to successful completion of the hauling operation.

2.4.3 Placing: The time and effort required to place shielding material around or on structures could vary significantly. The

amount of material to be placed with equipment or manual labor; the ratio of berm material to roof shielding; whether the material is handled from a dumped stock pile or obtained from a site source and accessibility or operating space around the structure are just some of the factors which must be considered. It might be possible to determine best placing method or operation for individual structures but in all probability, this operation will be accomplished in a more or less random fashion by matching available equipment and manpower as well as possible.

Table 2 gives an indication of the percent of material placed by equipment or hand methods. Although percentages would be different for each structure, it is assumed that about 60% of the material will be placed with equipment the remaining 40% with hand labor. This is approximately the same percentage as shown between berm and roof shielding material discussed previously.

Two placing situations are considered. The first where material has been hauled from a borrow pit and dumped in piles around or near the structure - Tasks D, E, F and G of Table 2; the other where material is obtained from a site source - Tasks H, I, J, and K. Placing requirements for trench type expedient shelters (Task M) would be similar to Task D; those for surface shelters (Tasks N or P) similar to tasks D or H depending on source of material. In cases where a site source is used, small bulldozers or backhoes would dig and/or stockpile the material. Anticipated production rates would be as shown on Table 8. Once the material has been stockpiled the actual placing operation would be the same for both situations.

Small loaders and dozers could be used to dig-haul and place where there is a source of material near the building. Figure 14 gives hourly production rates for these units based on travel distance between the digging site and the structure. Haul or tram distances of up to 250 yards shown for the loaders and 150 yards for small dozers are considered practical maximums for this type of equipment. Beyond that it would probably be more efficient to haul material by truck. Tables 10 and 11 provide different measures of the placing requirements, both from a stockpile and a nearby source. Table 12 summarizes equipment unit production for all tasks with the exception of truck hauling.

The quantity of material to be handled is taken as 60% of the total shielding quantity plus 10% waste. As an example, if 1000 spaces were to be upgraded, the placing equipment would handle 660 cu yds (1000 x 1 cu yd/space x 1.1 x .60). Hourly production would be obtained from Table 12. For Tasks H, I, J, K or P average distances to material sources are used and might have to be modified using Figure 14.

By comparing production rates for the same units of equipment on Table 8 and Table 12, it can be seen that there is a substantial reduction when using the unit for placing. The main reason for this is that no type of construction equipment is made with specific characteristics for placing shielding. Small loaders and dozers are the most adaptable for this operation. Although the percent of reduction varies, it can generally be assumed that the production of any unit in placing shielding

LOAD-HAUL-PLACE MATERIAL WITH SAME EQUIPMENT FROM NEARBY SOURCE

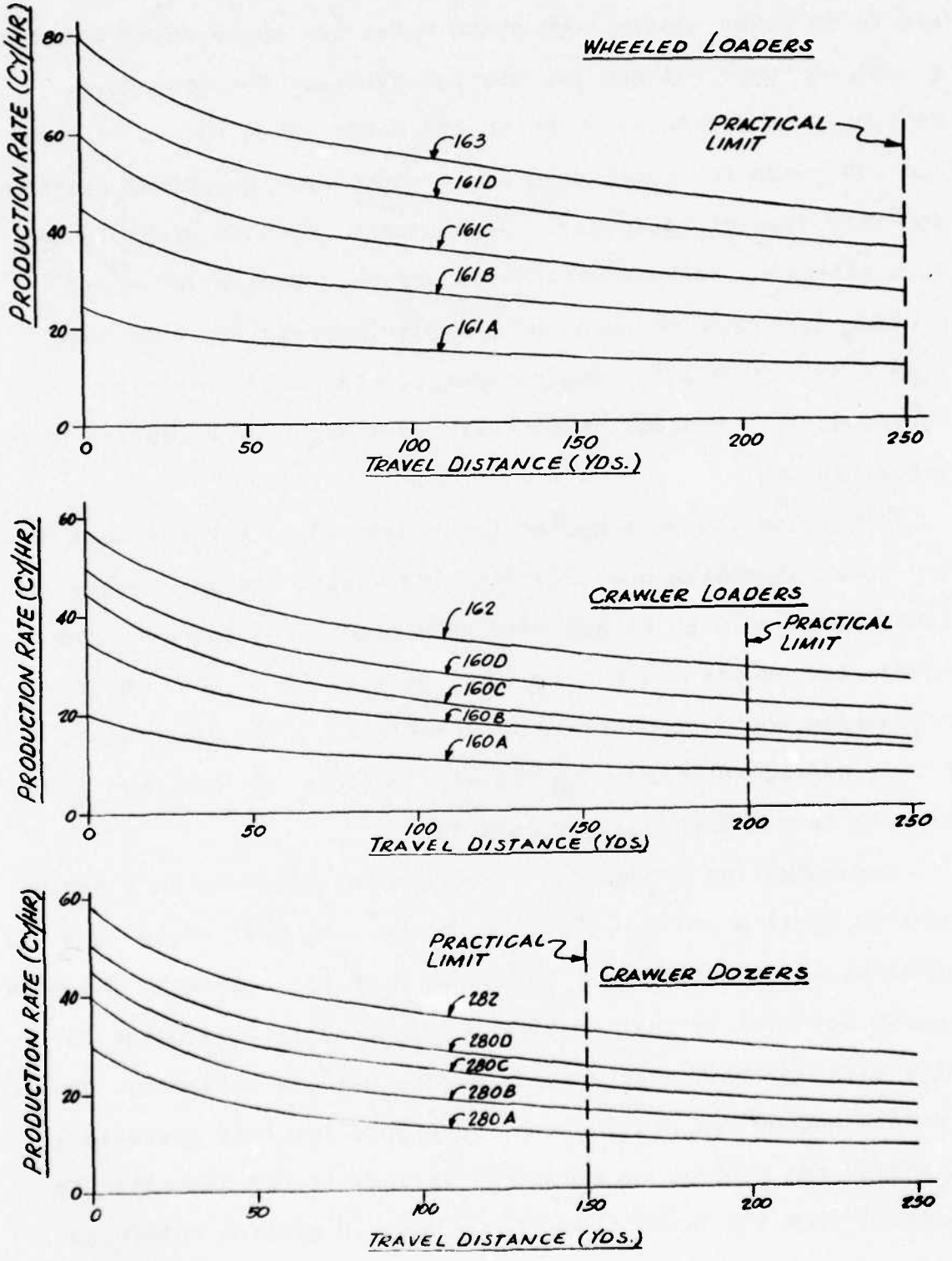


Figure 14

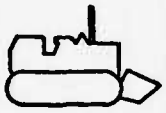
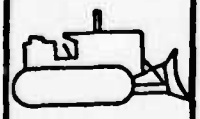
AMOUNT OF WALL SHIELDING (CU. YD.) PLACED PER UNIT IN ONE DAY (20 HRS.)						
TYPE OF EQUIPMENT	EQUIPMENT CODE	PLACE FROM STOCKPILE	DIG, HAUL & PLACE FROM LOCAL SOURCE			
			50 YDS	100 YDS	150 YDS	200 YDS
CRAWLER LOADER 	160A	400	260	220	180	160
	160B	700	440	360	300	260
	160C	900	560	480	400	340
	160D	1,000	680	580	500	440
	162	1,100	840	720	640	560
WHEELED LOADER 	161A	500	340	300	260	240
	161B	900	600	500	440	400
	161C	1,200	820	720	640	580
	161D	1,400	1,040	920	840	760
	163	1,600	1,220	1,100	1,000	900
CRAWLER DOZER 	280A	600	340	260	220	180
	280B	800	480	380	320	280
	280C	900	600	500	420	360
	280D	1,000	720	600	520	440
	282	1,100	840	720	640	560

Table 10

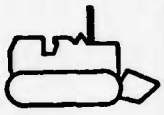
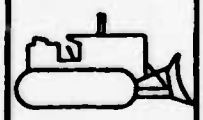
NUMBER OF HOURS REQUIRED PER UNIT TO PLACE 1000 CU. YD. OF WALL SHIELDING (BASED ON WORKING 20 HR/DAY)						
TYPE OF EQUIPMENT	EQUIPMENT CODE	PLACE FROM STOCKPILE	DIG, HAUL & PLACE FROM LOCAL SOURCE			
			50 YDS	100 YDS	150 YDS	200 YDS
CRAWLER LOADER 	160A	60	92	109	133	150
	160B	34	55	67	80	92
	160C	27	43	50	60	71
	160D	24	35	41	48	55
	162	22	29	33	38	43
WHEELED LOADER 	161A	48	71	80	92	100
	161B	27	40	48	55	60
	161C	20	29	33	38	41
	161D	17	23	26	29	32
	163	15	20	22	24	27
CRAWLER DOZER 	280A	40	71	92	109	133
	280B	30	50	63	75	86
	280C	27	40	48	57	67
	280D	24	33	40	46	55
	282	22	29	33	38	43

Table 11

TYPICAL EQUIPMENT TASK PRODUCTION RATES (CU.YD./HR.)

EQUIPMENT		EXCAVATE		LOAD	PLACE SHIELDING FROM STOCKPILE				EXCAVATE AT SITE & PLACE SHIELDING			
		TASK A_S	TASK A_H	TASK B	TASK D	TASK E	TASK F	TASK G	TASK H	TASK I	TASK J	TASK K
TYPE	CODE	SOFT EARTH	HARD EARTH	LOADERS ONLY	Single Building		Attached Bldg.		Single Building		Attached Bldg.	
					Gr Floor	Basement	Gr Floor	Basement	Gr Floor	Basement	Gr Floor	Basement
BACKHOE	020	70	55	In A_S&A_H	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	022	140	110	" "	"	"	"	"	"	"	"	"
	024	190	150	" "	"	"	"	"	"	"	"	"
SHOVEL	260	80	60	In A_S&A_H	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	262	160	130	" "	"	"	"	"	"	"	"	"
	264	220	180	" "	"	"	"	"	"	"	"	"
FRONT END LOADER (CRAWLER)	160A	20	10	30	25	22	19	17	18	15	13	10
	160B	35	20	55	45	40	35	30	30	28	25	18
	160C	50	30	75	55	50	45	40	40	35	30	22
	160D	65	35	100	70	65	55	50	50	42	35	28
	162	90	50	140	90	80	70	60	60	52	45	36
	164	120	70	140*	110	100	90	80	75	65	55	45
	166	160	90	140*	120	110	100	90	85	75	60	50
FRONT END LOADER (WHEELED)	161A	25	10	40	35	30	28	25	24	21	18	15
	161B	45	20	70	55	50	45	40	40	35	30	22
	161C	65	30	100	75	67	60	50	50	45	40	30
	161D	90	45	130	90	80	70	60	60	52	45	35
	163	120	60	185	120	110	95	85	85	75	60	50
	165	160	80	185*	140	125	110	100	95	85	70	58
	167	200	100	185*	160	145	125	110	105	95	80	65
DOZER (CRAWLER)	280A	60	45**	N.A.	35	35	30	30	25	25	20	20
	280B	85	65**	"	45	45	40	40	30	30	25	25
	280C	110	85**	"	50	50	45	45	35	35	30	30
	280D	140	110**	"	55	55	50	50	40	40	35	35
	282	230	180**	"	65	65	55	55	45	45	40	40
	284	330	260**	"	75	75	65	65	50	50	45	45
	286	400	320**	"	85	85	75	75	60	60	50	50
	288	520	420**	"	95	95	85	85	70	70	60	60
AVERAGE OF ALL "HOST COUNTY" UNITS					69	64	56	51	47	43	37	32
AVERAGE OF SMALL UNITS (TO 150 HP) ONLY					54	50	44	40	38	34	29	24

NOTES * Production limited by truck capacity
**Equipped with rippers

Table 12

material would be 40 to 60% less than would be considered for a dig-load operation. For instance, if a code 024 backhoe was used to excavate the trench for an expedient shelter, anticipated production would be 130 cu yds per hour (Table 7). If the same unit was subsequently used to place shielding, a production of about 80 cu yds/hour could be expected.

It has been assumed that 60% of shielding will be placed with equipment -- the other 40% by hand labor -- with each operation considered separately. In all likelihood however, both equipment and hand placing would be carried on simultaneously which poses the problem of interference between labor and equipment. In some instances the equipment may remain at a structure until the task is complete, regardless of whether or not it is placing material or merely being used to help hand labor in such ways as lifting material to the roof.

These and other conditions make it difficult to specify equipment productions for the placing operation. However, the rates given in Table 12 should be reasonable for most situations.

2.4.4 Summary: Production obtained by different units of equipment can be fairly well defined under certain set conditions. Unfortunately, crisis period tasks do not lend themselves to such an analysis since conditions could vary significantly between or within different host areas. This is especially true of the placing operation where very little if any past experience can be called upon. Although front-end loaders are best suited for the task, placing shielding material against the wall of a building requires both competent operators

and careful supervision. A large unit could easily demolish the wall if used improperly.

The types and sizes of equipment considered are representative of typical equipment resources to be found in most risk and host areas. If different units were available they would be used to the extent possible. In this case the planner would use adjusted production rates obtained by comparing size or capacities of available equipment with those that are specified.

Considering crisis period tasks as discussed in Section 1 and the equipment units and production rates given in this section, a summary tabulation has been prepared which provides a guide in determining equipment production for all tasks -- Table 12. The type and code numbers of units are listed in the left hand columns. Anticipated production in cubic yards per hour is shown for each unit with respect to tasks A and B and D through K as listed on Table 2. If a separate dig-load haul operation was used in lieu of the site source considered for Tasks H - K, then the hourly production rates would be the same as shown for Tasks D - G. The production rate to be achieved for the placing operation is difficult to predict and in all likelihood would be accomplished by using a mix of equipment and manpower available at the particular time. The bottom two lines of Table 12 show estimates of production which could be achieved when using an average mix of equipment, either all considered units or only those units less than 150 HP capacity. These production rates could be used in making a general evaluation of equipment requirements for the placing operation. Production rates for expedient shelter tasks would be similar to those

shown on Table 12. Anticipated production for task C (Hauling) would be obtained as discussed in paragraph 2.4.2. Section 4 of the report explains how Table 12 is used for a particular situation.

2.5 EQUIPMENT GROUPS

For most earth moving projects it is normal to set up typical equipment spreads or groups which can accomplish a specific task usually involving a significant quantity of material. However, with the exception of the dig-load and haul operation from a borrow pit, crisis period tasks are so varied that it would be impractical to establish pre-determined groups.

Typical equipment used for the dig-load operations are shown on Tables 7 and 8. Although single or muliple units of the same type could be used, the most efficient group would be a combination of bulldozer and front-end loader. The two lower tabulations of Table 7 can be used as a guide to determine best grouping of these units with respect to available equipment. To complete the group it would be necessary to match truck size and number with anticipated pit production. Figures 11, 12 and 13 give an indication of truck requirements. Groups of dig-load and haul equipment which would probably be typical for most areas are shown in Table 13. Requirements are based on hourly production and length of haul.

Equipment for other tasks such as placing or building expedient shelters would be considered as individual units. In most instances, the use of bulldozers for loosening or stock piling material will improve production even though other units such as front-end loaders are used to load or place the material.

MULTIPLE UNIT OPERATIONS TYPICAL DIG-LOAD-HAUL GROUPS						
PRODUCTION RATE	EXCAVATING UNITS	LOADING UNITS	HAULING BY DUMP TRUCKS DISTANCE HAULED			
			0.5 MILE	1 MILE	2 MILES	5 MILES
100 CY/HR	Backhoe 1 - 022		4 @ 5 cy	5 @ 5 cy	8 @ 5 cy	12 @ 5 cy
200 CY/HR	Shovel 1 - 264		6 @ 5 cy	9 @ 5 cy	15 @ 5 cy	9 @ 10 cy
300 CY/HR	Dozer 1 - 284	Loader 2 - 163	5 @ 10 cy	8 @ 10 cy	11 @ 10 cy	18 @ 10 cy
400 CY/HR	Dozer 1 - 286	Loader 2 - 165	4 @ 20 cy	5 @ 20 cy	8 @ 20 cy	12 @ 20 cy

Table 13

2.6 LABOR AND OTHER RESOURCES

Most equipment operations require labor other than operators, drivers and mechanics for successful completion. Flagmen and dumpmen would be needed for the hauling operation. If a fairly large borrow pit is used, it would be necessary to have a "pit boss" directing the movement of trucks and equipment. Laborers will be needed to cover windows and make entrance ways. The shielding material to be placed by hand will require a large number of men. Since these manual requirements affect equipment utilization, they must be considered in overall evaluations.

A general indication of manual productivity when placing shielding material around or on structures can be obtained from previous studies and actual experiments as noted in References 4 and 6. Those studies show that placing roof shielding with experienced laborers requires from 1.7 to 5 man hours per 1 cubic yard. When shoveling loose material into a wheelbarrow, one man would load about one cubic yard per hour. If the material had to be moved 50 feet or so it would require another 2 or 3 men to handle the wheelbarrows. The overall efficiency of relatively inexperienced labor used during the crises period will probably be 30 - 50% less than could be expected from experienced construction workers.

A general appraisal of labor requirements for upgrading tasks is shown on Table 14. The upper portion indicates additional labor as may be required for the dig-load-haul operations. Number of men could vary significantly depending on size

UPGRADABLE & EXPEDIENT SHELTERS SUPPORTING LABOR REQUIREMENTS	
DIG-LOAD-HAUL OPERATIONS	
Classification	Number Required
Pit Boss	
Signalmen	2 - 5
Flagmen	5 - 10
Dumpmen	2 - 5
General Laborers	1 - 10
MANUAL TASKS	
Operation	Man-hours/cu yd*
Excavate soft material	0.8 - 1.2
Excavate hard material	1.5 - 2.5
Load wheelbarrows or buckets	0.5 - 1.3
Haul with wheelbarrows	0.5 - 1.0
Roof shielding	
Bucket brigade	5.0 - 8.0
Hoist with equipment	2.0 - 5.0
Floor shielding	3.0 - 5.0
Wall shielding	2.5 - 4.5

*Includes allowances for incidental tasks such as covering windows or making entrances. Does not include building of structural frames for expedient shelters.

Table 14

of the operation and length and complexity of haul. The lower portion of the table shows approximate number of manhours per cubic yard required for different hand excavating and placing tasks. The planner would have to consider various combinations of the individual operations and respective man hour requirements to approximate conditions applicable to a specific situation. If the predominate operation is to load stockpiled material into buckets and place it on the roof by means of a bucket brigade, the manhours per cubic yard would vary from 5.5 to 9.3. These determined man hour requirements would be applied against the quantity placed by hand which is assumed as being about 40% of the total. For instance, if 6,000 cu yds (including waste) was required for a task, approximately 17,760 man hours of labor would be required $\left[6{,}000 \times .40 \times \frac{(5.5 + 9.3)}{2}\right]$. Assuming each individual worked one 8 hour shift per day, it would require 740 men to complete the task in three days on a three shifts per day basis.

The man hour requirements shown on Table 14 include allowances for incidental tasks such as making entrances etc.

Even though a good portion of upgrading tasks will be accomplished with equipment, it is obvious that a large amount of manual labor will also be needed. This will require close coordination with equipment planning.

Since operations will be carried on around the clock, it will be necessary to provide lights at pits, structures or expedient shelter sites. Pickups or flatbed trucks will be required for supervisory personnel and transportation of crews.

Fuel and servicing vehicles will be needed. Other resources such as protective clothing and small tools must be provided. Most of these resources including large numbers of shovels and wheelbarrows, should be included in the overall CRP planning.

2.7 SUMMARY

Utilization of equipment during a crisis or emergency may not always proceed in accordance with what may have been considered well made plans and schedules. Consequently the planner or his equipment manager must be able to improvise equipment assignments on the basis of general understanding of task requirements and equipment availability and productivity.

This section provides general guidelines which should help in this respect. Types and sizes of equipment most likely to be used are identified along with operating requirements and anticipated hourly production rates for a variety of tasks.

Top priority should be given to delivering needed shielding material around the various structures to be upgraded. This could best be accomplished by assigning largest available dig-load units to a borrow pit along with adequate trucking capacity. Once material is distributed, this equipment could be used in conjunction with smaller units in performing the actual placing operation. As relocatees are brought into the area they could help with the placing operation on the basis of assignment to particular structures. Although the main concern would be to provide adequate shelter for all, it must be kept in mind that working heavy equipment in and around a large group of essentially inexperienced people could be dangerous unless competent

operators are used and all operations are under careful supervision.

SECTION 3

EQUIPMENT AVAILABILITY

3.1 GENERAL

Providing adequate shelter facilities for both host and risk area populations within a 3 day period requires an immediate start of efficient operations at the beginning of the crisis period. This means that all equipment must be adequately identified with respect to type, size and location, and readied for assignment to specific tasks. The required inventorying and allocation plan must be finalized in advance of the crisis determination.

While it would be convenient to have a complete up-to-date inventory of equipment for all potential risk and host areas in the United States, no such inventory exists at present, nor is it likely that such an inventory will be made in the foreseeable future. However, the need caused by a national emergency is such that problems and time involved in making an inventory would be well justified.

Construction companies, and their equipment, are highly mobile and move as construction projects dictate. Thousands of new units are manufactured each year while thousands of older units are scrapped. Replacements are not always on a one to one basis; new equipment is purchased as needed. Construction companies themselves are not always stable due to an inconstant market. Companies going out of business sell their equipment to other companies, equipment rental firms or speculators.

Because of these factors, equipment inventories for a particular area may be outdated before they have been completed, and unless diligently updated periodically, soon become obsolete.

This section of the report discusses various procedures and methods which could be used by the planner in assessing the availability of equipment resources within his area. Two possibilities exist - a general evaluation based on statistical averages or a specific analysis based on conventional inventorying procedures.

3.2 STATISTICAL DISTRIBUTION OF EQUIPMENT

The amount and relative mix of equipment will vary for every county in each state, and vary from year to year. However, it is possible to provide broad guidelines so the planner will have an idea of what he could expect to find both in the rural host area and the urban risk area whose evacuees must be provided for. In general, large size equipment will be found concentrated in the urban areas where most construction projects are located, while smaller sized equipment for building foundations and utility trenching will predominate in smaller communities. Notable exceptions would be areas where projects such as dam construction or highway construction are in progress, or where mining operations are located. These types of work require larger equipment than is normally found in rural towns.

This distribution of large equipment in urban areas and small equipment in rural areas is opportune for the crisis planner, as it results in a minimum amount of equipment reloca-

tion. Smaller loaders and dozers are most useful for shielding operations in the host area. Larger equipment would be required in the risk area for clearing paths through debris or other emergency operations in the aftermath of a nuclear explosion. Small equipment is not effective for this type of work, which must be done rapidly and as soon after the attack as possible.

3.2.1 Estimate of Total Units - U.S.A.: Estimates of major categories of equipment located in general national regions were made in assessing the construction industry's post-attack capabilities for debris removal (Ref. 10 - Van Horn). Those estimates considered both track-mounted and rubber-tired bulldozers, loaders and tractors and were based on information obtained from government and private sources for the period 1961 to 1970. Starting from an estimate of total units available, (excluding farm use) an approximation was made of the number and types of units suitable for debris clearing (generally larger than 100 horsepower, over 2 cu yd capacity, etc.). A general indication of the distribution of equipment was made by relating total units to statistical data - such as dollar volume of construction - pertaining to geographic areas and types of industries.

Following a similar procedure, but using more recent statistics obtained from the U.S. Department of Commerce (Ref. 11 & 12), new estimates were prepared to determine the availability of wheeled front-end loaders and bulldozers. These new estimates included the smaller units of equipment useful for

preparation of shelter spaces during the crisis period. Results, which are shown on the upper portion of Table 15, give an indication of the total number of these units available within the United States. The lower portion of Table 15 shows the total estimated units currently available plus an evaluation of track-type loaders taken from Reference 10. Assumptions are given of the number of units available for CRP operations on the basis of population, in urban and rural areas.

The number of units shown on Table 15 reflect a ten year average life for all equipment which is consistent with industry practice. Some of the assumptions used in preparing the estimates are:

1. While the number of units exported have been deducted from the total manufactured, no addition has been made for imports. Although imports are low compared to total U.S. figures, this tends to make the summaries slightly conservative.
2. No distinction is made in published data of how many tractors are used as tow units or bulldozers. Since the total number of tractors far exceeds the number of manufactured dozer blades, the latter figure is used to estimate the number of available bulldozers. (Dozers - Table 15.)
3. The number of wheeled dozers is comparatively small compared to crawler dozers and therefore not considered separately in the estimate. In areas where wheeled dozers are found, they can be considered as

SELECTED EQUIPMENT MANUFACTURED IN U.S.A. 1966 - 1975						
YEAR	ALL WHEELED F.E.L. OVER 35 HP			ALL DOZERS, OVER 6 FT. BLADE		
	TOTAL	EXPORT	U.S.A.	TOTAL	EXPORT	U.S.A.
1975	21,100	5,300	15,800	17,600	7,500	10,100
1974	24,800	4,900	19,900	20,200	6,500	13,700
1973	29,500	5,100	24,400	17,800	5,400	12,400
1972	25,200	4,500	20,700	16,700	4,800	11,900
1971	18,700	3,400	15,300	14,800	4,700	10,100
1970	17,200	4,200	13,000	17,400	5,600	11,800
SUB TOTAL	136,500	27,400	109,100	104,500	34,500	70,000
1969	Interpolated		12,500	Interpolated		11,500
1968			11,000			11,000
1967			9,500			10,000
1966			9,500			11,500
TOTAL ESTIMATED			151,600			114,000

ESTIMATE TOTALS

*LOADERS (TRACK)	83,000	(24%)
LOADERS (WHEEL)	151,600	(43%)
DOZERS (BOTH)	114,000	(33%)
	348,600 UNITS	

ASSUME 80% IN CONSTRUCTION: 278,900 UNITS

AVERAGE FOR 214 MILLION PEOPLE: 1 UNIT/770 PEOPLE

AVERAGE IN URBAN AREAS 1 UNIT/900 PEOPLE
AVERAGE IN RURAL AREAS 1 UNIT/600 PEOPLE

*From Reference 10

Table 15

performing in like manner to comparable sized crawler units, for the type of work considered here.

4. For yearly periods where details of manufactured units are not available, the total dollar value of equipment has been converted into an approximate number of units by applying published yearly construction equipment cost indexes.

5. Approximately 80% of dozers and loaders are used by the construction industry, government agencies and public utilities, which for purposes of this study are assumed as primary sources of equipment for CRP operations. The remaining 20% used in agriculture and mining could be made available if not required for critical functions within their respective industries. This approach also tends to make the estimates conservative.

3.2.2 Distribution of Equipment in Urban and Rural Areas: Having estimated the total number of units available in 1975, it is necessary to use some rationale for estimating distribution of this equipment between rural host and urban risk areas. Van Horn indicates that the distribution of equipment among four regions is more closely related to population than to area. In the example cited with widely divergent population densities, the number of units per 10,000 population varied by a factor of 1.5, with high density areas having fewer units per 10,000 population than low density areas. The areal density of the units for the same regions varied by a factor of 10.

The distribution of equipment on basis of population seems logical and consistent with other data on construction activities. All communities have some local construction companies for buildings, roads and utilities. In urban areas projects are proportionately larger, but concentrated in a smaller area where travel considerations allow for less units to perform equivalent amounts of work.

Another indication of equipment distribution can be made based on a computer printout of an economic profile of Colorado Counties (Ref. 13). The printout gives names, location and number of employees for a wide variety of Standard Industrial Classification (SIC) numbered industries. The following is an example of how that data can be used to obtain an approximation of equipment distribution.

The number and employees of companies with SIC number 1794 - "Excavating Contractors" - are compared for El Paso County (Colorado Springs) and Fremont County. The number of Excavating Contractor's employees should reflect a proportion to the number of equipment units used. The tabulation shows that the number of employees in this industry, compared to total populations of their respective counties, is about 50% more per 10,000 population in Fremont County (low density) than El Paso County (high density). This is the same proportion with respect to population as determined for the crawler tractors in the example of the Van Horn report and as indicated on the bottom portion of Table 15.

RELATIONSHIP OF EXCAVATING CONTRACTORS EMPLOYEES TO TOTAL POPULATION

From recent D & B data printout for Colorado Counties, SIC 1794 only - Excavating Contractors

EL PASO COUNTY	36 companies	204 employees
Outside Colorado Springs	-7 "	-25 "
Colorado Springs only	29 companies	179 employees
FREMONT COUNTY	9 companies	24 employees

Ratio to Total Population:

Fremont County $20{,}000 \div 24 = 833$

Colorado Springs $227{,}000 \div 179 = 1268$

$$833 : 1268 = 1 : 1.5$$

This distribution by population factor is used to find an average proportion of loader and dozer units in host and risk areas. For the purpose of this study, a metropolitan area of 100,000 or more is considered urban. In the United States, two thirds of the population live in cities of 100,000 or more. The national average of units per population in conjunction with the rural/urban factor of 1.5 can be used to determine a weighted number of equipment units for each area. For the three types of equipment considered in Table 15, it is shown that one unit is available nationally for each 770 people. This means approximately one unit per 600 people in rural areas and one unit per 900 people in urban areas.

Applying these average units per population to the hypothetical host and risk areas discussed in Sections 1 and 2, we

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UTILIZATION OF EQUIPMENT CRISIS RELOCATION PROGRAM.(U)
SEP 77 G E WICKHAM, H R TIEDEMANN DCPA02-76-C-0306
UNCLASSIFIED JA-TR-145 NL

2 OF 2
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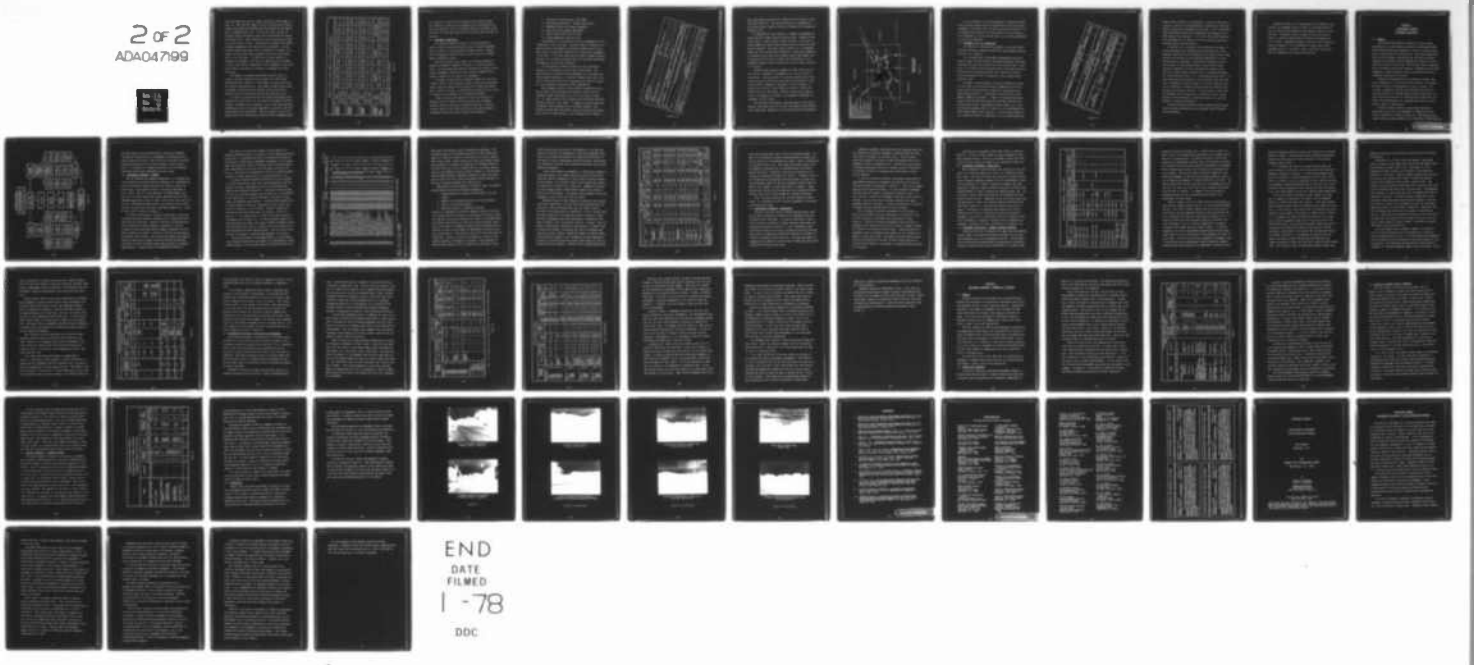

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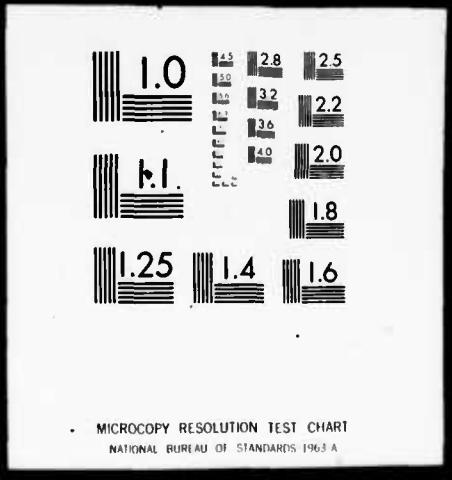


find the number and type of loaders and dozers units shown in Table 16. The relative number of units for each size reflects roughly the proportion manufactured and reported by the Department of Commerce (Ref. 12). In the rural area, the mix is weighted toward the smaller units and in the urban area toward the larger units. Only a portion of units that might be found in the risk area is shown. This portion is based on the number of people assigned to the host area for relocation. If the 40,000 evacuees come from a city of 200,000 for instance, the number of units shown would represent 20% of the total available in the risk area. If there is to be any transfer or exchange of equipment, this gives an indication of the number of units that could be considered. Other equipment in the risk area would be available for transfer or exchange with other host areas.

The number of backhoes and shovels noted on Table 16 reflect a general proportion of the number of these units manufactured with respect to total number of dozers and front-end loaders (National basis). The number of dump trucks shown is probably conservative but could be readily verified by checking vehicle registrations within any particular area.

It should be reiterated that the numbers developed do not represent any particular area but rather an estimated national average. Equipment within specific risk or host areas may vary considerably from this average depending on location, time and local construction conditions. They do, however, give a reasonable basis for preliminary estimates of what equipment might

NUMBER OF UNITS IN "HOST COUNTY" & "RISK CITY" (PARTIAL)*										
CRAWLER LOADERS	CODE	TOTAL	160A	160B	160C	160D	162	164	166	-
	Host County	8	2	2	1	1	1	1	-	-
	Risk City*	11	1	1	1	2	2	2	2	-
WHEELED LOADERS	CODE	TOTAL	161A	161B	161C	161D	163	165	167	169
	Host County	15	3	3	2	2	2	1	1	1
	Risk City*	19	2	2	2	2	2	3	3	3
CRAWLER DOZERS	CODE	TOTAL	280A	280B	280C	280D	282	284	286	288
	Host County	11	2	2	2	1	1	1	1	1
	Risk City*	14	1	1	1	2	2	2	3	2
BACKHOES SHOVELS & DUMP TRUCKS	TYPE	BACKHOES			SHOVELS			DUMP TRUCKS		
	CODE	020	022	024	260	262	264	5 CY	10 CY	20 CY
	Host County	1	1	-	1	1	-	20	15	10
	Risk City*	1	1	1	1	1	1	25	20	15

*Portion of equipment based on number of evacuees

Table 16

be available in either area to perform crisis period tasks. For instance, if the host area population was 200,000 and the risk area 400,000, then the estimated number of equipment units available for CRP operations would be 10 times that as shown on Table 16.

3.3 EQUIPMENT INVENTORIES

In a period of mounting crisis, it would probably be easier to make a rapid and accurate count of usable equipment than it would be in a period when no danger exists. People will be cooperative and willing to help if they are informed what is expected of them.

One of the aims of this report is to aid the planner to prepare an adequate equipment inventory in a short period of time. A survey requesting specific information relating to the type of equipment needed will bring a better response than a general request for all data on all equipment.

The types of construction equipment needed are front-end loaders, dozers, earth excavators such as shovels and backhoes, dump trucks and flatbed trucks capable of transporting equipment. Table 5 provides a classification code which can be used to identify this equipment for inventoring purposes.

Either checking and updating an existing inventory or making a new one requires personal contact with equipment owners to acquire necessary information and data. The main sources, many of which would be found in the yellow pages of telephone directories, would include the following:

1. Contractor's Associations - AGC, EEGC
2. Excavating Contractors - General Contractors
3. Equipment dealers and rental companies
4. State and local highway departments
5. Public and private utility firms
6. Mining companies, quarries, etc.

The planner in a rural host area has an advantage over his counterpart in the risk area. Initial contact in person or by phone of one or two people in the above categories will probably result in sufficient information to locate most equipment in his area. In a large urban area the task is proportionately greater, as it would be unlikely that any individual would have knowledge of all available equipment.

If time permits, personal contact with the individual owners will bring better results than a form letter. The owners should be advised how the equipment is to be used, and what minimum information is required. Sample forms that can be used to obtain and record this information are shown in Figure 15. The information headings are self explanatory.

Each equipment source or yard should be identified with a serial number which designates the general location of the equipment (upper right hand entry of the top form of Figure 15). In some instances this location may be different than the business location of the owner. A separate inventory form will be made for each equipment base or storage location, even though the same owner may control several such bases and therefore listed in several forms. Serial numbers can be shown in

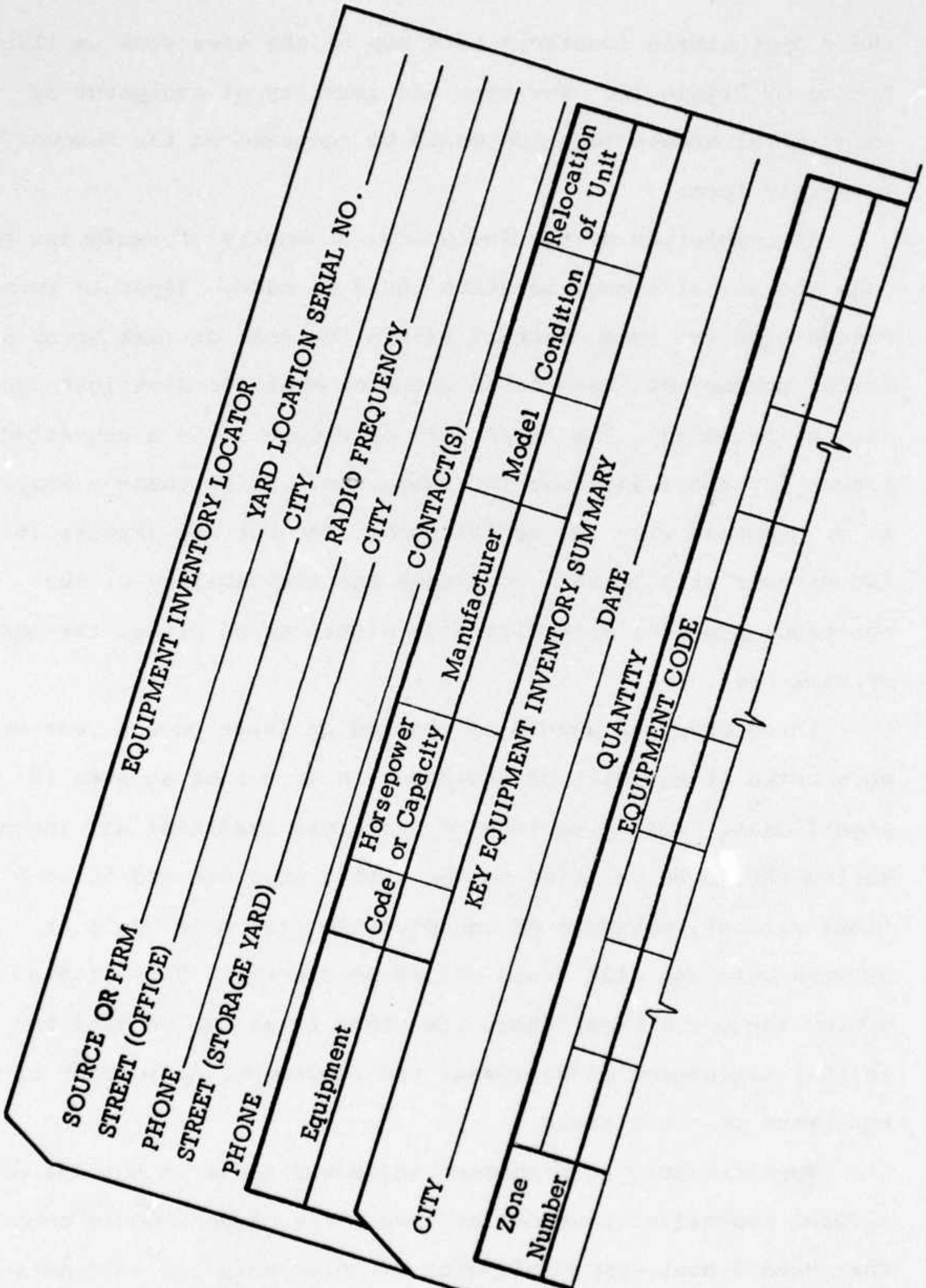

EQUIPMENT INVENTORY LOCATOR
SOURCE OR FIRM
YARD LOCATION SERIAL NO.
STREET (OFFICE)
CITY
PHONE
RADIO FREQUENCY
STREET (STORAGE YARD)
CITY
PHONE
CONTACT(S)
Equipment
Code
Horsepower or Capacity
Manufacturer
Model
Condition
Relocation of Unit
CITY
KEY EQUIPMENT INVENTORY SUMMARY
DATE
QUANTITY
EQUIPMENT CODE
Zone Number

Figure 15

their approximate locations on a map of the area such as illustrated by Figure 16. The type and quantity of equipment at each serial number location would be recorded on the respective inventory form.

At completion of the inventory, a summary of equipment by code and serial number location would be made. Separate forms can be used for each district within the host or risk area. A master summary of these forms based on areas or districts could then be prepared. The lower form of Figure 15 is a suggested format for local and district summaries. Using these summaries in conjunction with the serial number locator map (Figure 16), the planner will be able to assess the availability of the equipment resource within various districts of either the host or risk area.

Inventory data should be updated at least once a year or more often if movement of equipment in or out of an area is significant. During periods of increased readiness all inventories should be verified to the extent possible and if conditions warrant, movement of equipment to risk area MSA's or between host and risk areas should be started. Once crisis period tasks are undertaken, inventory forms can be used for initial assignment of equipment and subsequent deployment of equipment to other tasks.

The inventorying procedure suggested above is but one of several techniques that can be used. The planner would choose that method most compatible with existing data and information.

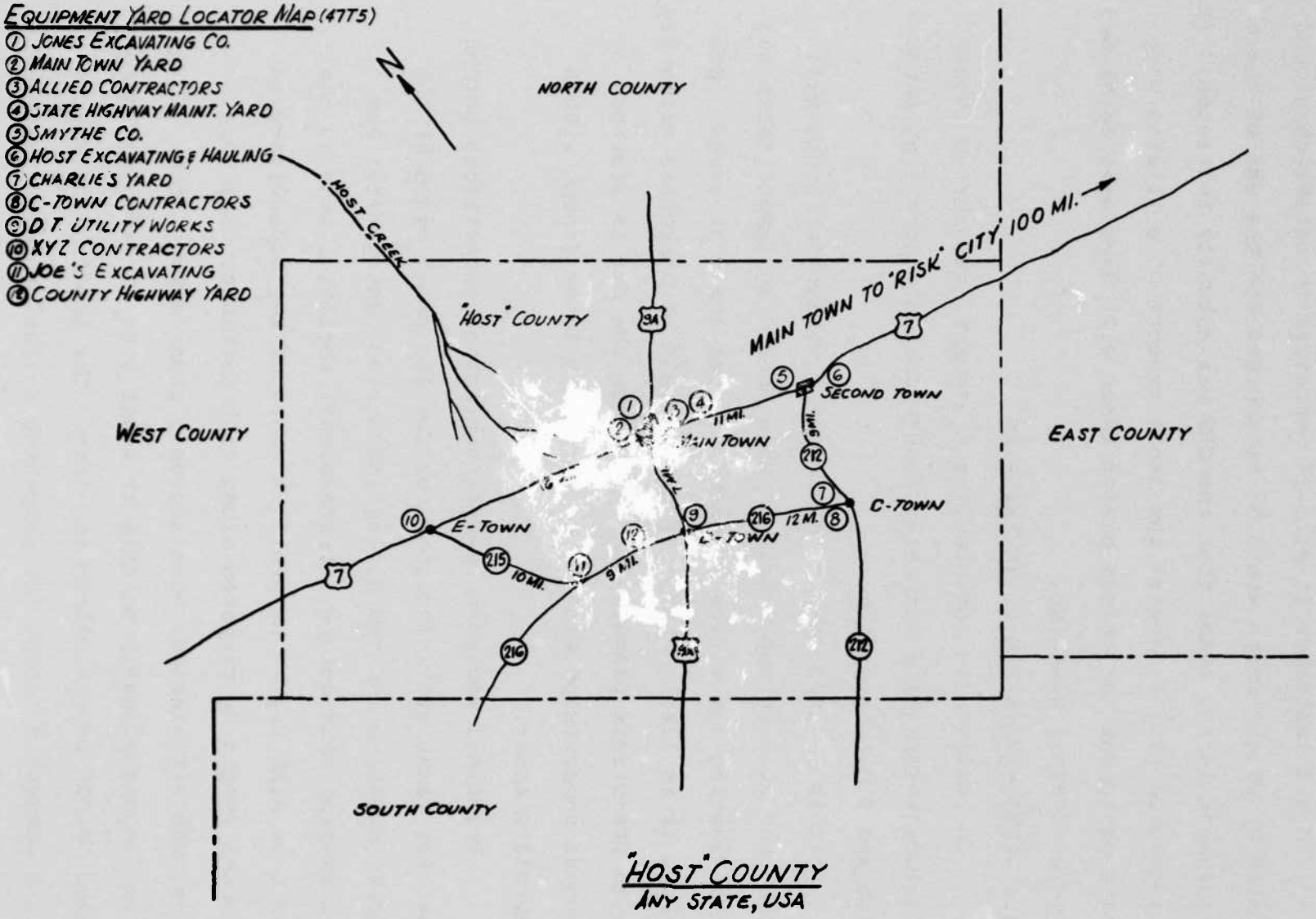

EQUIPMENT YARD LOCATOR MAP (4TT5)
1 JONES EXCAVATING CO.
2 MAIN TOWN YARD
3 ALLIED CONTRACTORS
4 STATE HIGHWAY MAINT. YARD
5 SMYTHE CO.
6 HOST EXCAVATING & HAULING
7 CHARLIE'S YARD
8 C-TOWN CONTRACTORS
9 D T UTILITY WORKS
10 XYZ CONTRACTORS
11 JOE'S EXCAVATING
12 COUNTY HIGHWAY YARD
N
NORTH COUNTY
HOST CREEK
"HOST" COUNTY
MAIN TOWN TO "RISK" CITY 100 MI.
SECOND TOWN
11 MI.
MAIN TOWN
9 MI.
WEST COUNTY
EAST COUNTY
C-TOWN
E-TOWN
10 MI.
9 MI.
12 MI.
SOUTH COUNTY
"HOST" COUNTY
ANY STATE, USA

Figure 16

In all instances it will be necessary to establish ground rules by which owners would be reimbursed for the use of their equipment in the event that the CRP was actually initiated. It is assumed that financial and legal aspects of utilizing private equipment for crisis period tasks will have been developed in the overall planning.

3.4 PERSONNEL & P.O.L. INVENTORIES

In addition to inventorying equipment, the survey should include information regarding supervisory and operating personnel and P.O.L. supplies.

It is assumed that a governmental management group will take the lead in supervising crisis period equipment tasks and coordinating activities between the risk and host areas. However, it is likely that this group would be concerned primarily with pre-crisis planning and that once the CRP is started, actual supervision will be delegated to local groups within specific areas.

Principal non-governmental sources of supervisory personnel for tasks utilizing construction equipment would be the heavy construction and mining industries, and general and excavating contractors. Professional societies such as the ASCE or AIME may be helpful. A cadre of key supervisory personnel should be prepared along with pertinent data such as business affiliation, home address, phone number, etc. This list should probably contain at least 5 to 10 individuals for each 50,000 people within the area. The top form of Figure 17 is a suggested format for compiling a list of supervisory per-

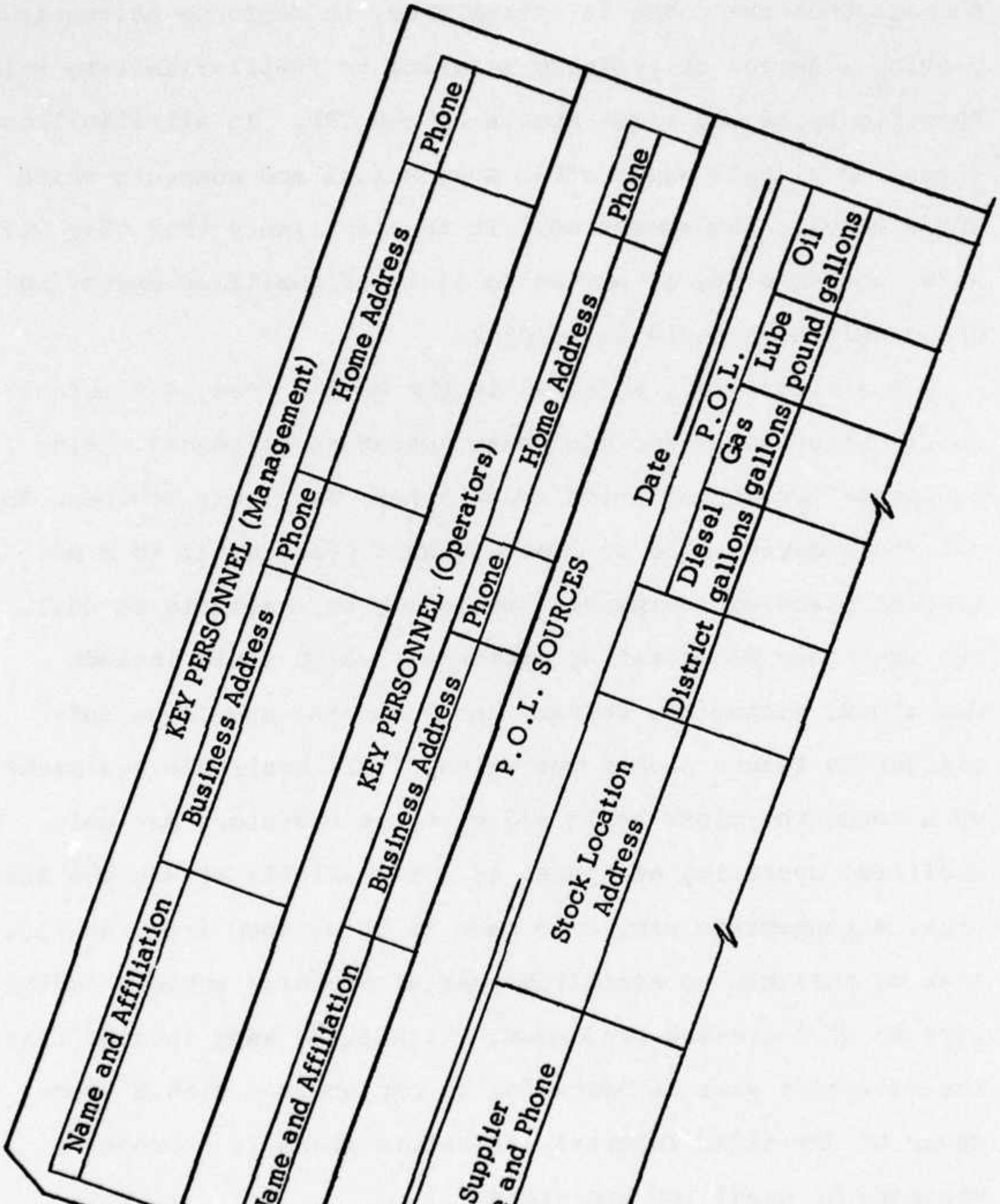

KEY PERSONNEL (Management)
Name and Affiliation
Business Address
Phone
Home Address
Phone
KEY PERSONNEL (Operators)
Name and Affiliation
Business Address
Phone
Home Address
Phone
P.O.L. SOURCES
City
Date
Supplier Name and Phone
Stock Location Address
District
P.O.L.
Diesel gallons
Gas gallons
Lube pound
Oil gallons

Figure 17

sonnel. Once the cadre is established, it would be advisable to provide a series of training sessions to familiarize them with specific tasks and requirements of the CRP. In all likelihood, these individuals would offer suggestions and comments which would benefit the operation. It is also likely that they will have knowledge of, or access to lists of qualified operating personnel which would be helpful.

A similar list, as shown in the second form of Figure 17 should be prepared for equipment operating personnel, using equipment owners and union headquarters as likely sources. Some operators may be more or less assigned permanently to a particular piece of equipment, others may be available on call. The inventory of operating personnel, which would include operators, mechanics, drivers and laborers, should be sufficient to insure proper operation of all available equipment on a round-the-clock basis - i.e. three operators per unit. If qualified operating personnel is not available within the host area, arrangements should be made to bring them from the risk area or possibly to establish special training schools during periods of increased readiness. It must be kept in mind that the equipment will be operating in conjunction with a large group of untrained laborers, therefore there is no room for amateurs or unskilled operators.

Briefing sessions should be held to familiarize the operators with CRP requirements and to acquaint them with supervisory personnel.

Although initial P.O.L. requirements will probably be supplied at the equipment source, needs for continued operation will be obtained from commercial distribution channels within the area. A tabulation such as shown on the third form of Figure 17 should be made showing the source and quantity of P.O.L. stocks. Appropriate means of delivery, fuel trucks etc. should be planned. It is preferable to refuel and service equipment where it is working, rather than take the time to move the equipment to a central fueling area.

SECTION 4

CONTINGENCY PLANNING

EQUIPMENT UTILITATION

4.1 GENERAL

The earth moving operation required to create shelter protection for a large population during a 3-day period needs pre-determined plans and procedures in order to utilize equipment or manual operations effectively. Since past experiences cannot be called upon, these plans must be based on results obtained from studying various hypothetical situations anticipated during the crisis period. By analyzing several possibilities, the planner should soon develop a reasonable plan of what equipment or manual operation would be required and used to accomplish tasks within his area.

Although requirements would be different for each area, basic fundamentals of all plans would be similar; the primary difference being in the magnitude of tasks involved. For instance, equipment utilization and procedures followed in providing shelter for 500,000 people would be essentially the same as providing shelter for 100,000 people except that the amount of shielding material, equipment and effort required would be about 5 times greater.

A general diagram showing various steps involved in developing a plan for using equipment to improve host area shelter capacities is shown on Figure 18. The diagram illustrates only one of many aspects to be considered in CRP planning

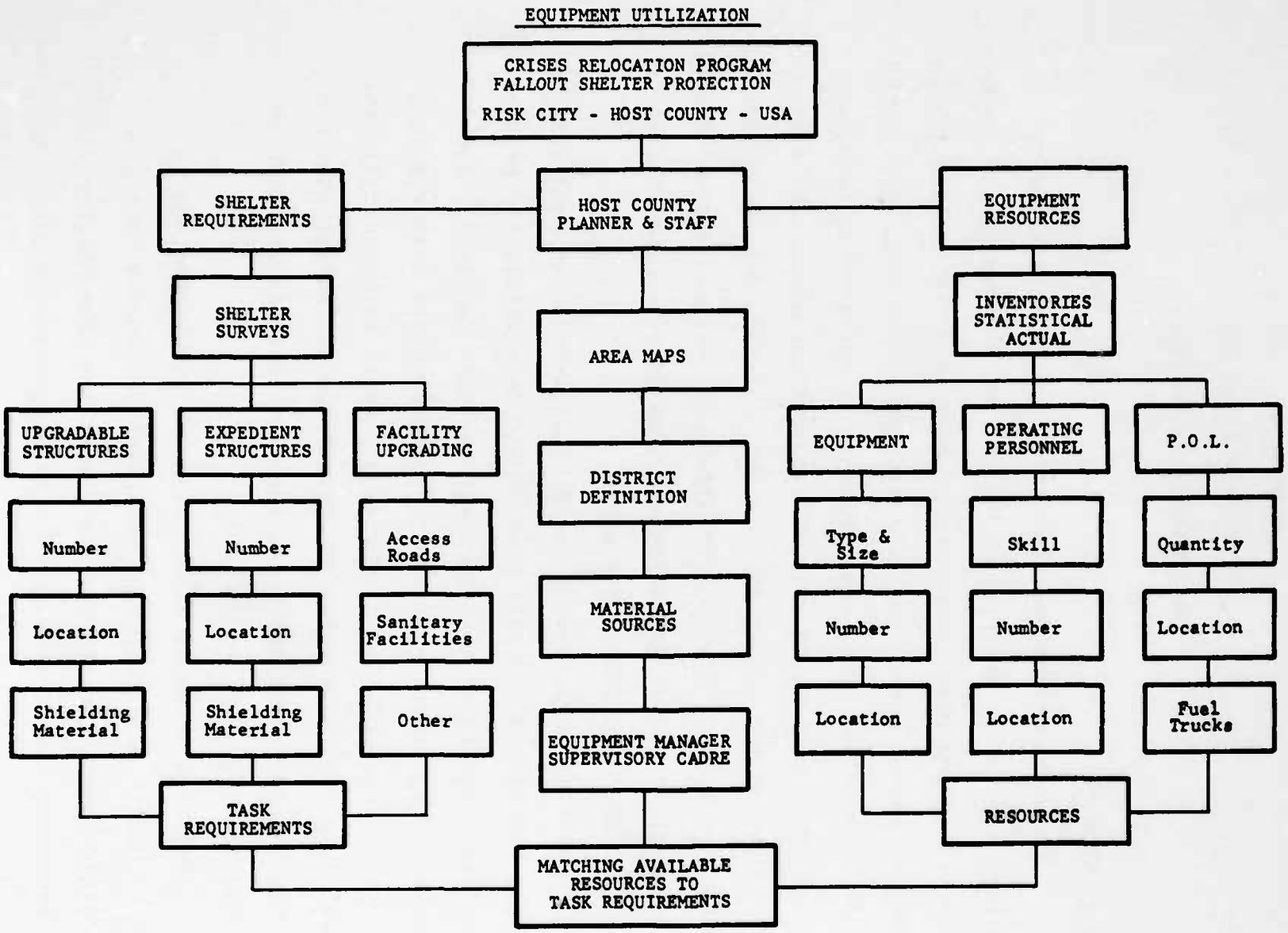

EQUIPMENT UTILIZATION
CRISES RELOCATION PROGRAM
FALLOUT SHELTER PROTECTION
RISK CITY - HOST COUNTY - USA
SHELTER REQUIREMENTS
HOST COUNTY PLANNER & STAFF
EQUIPMENT RESOURCES
SHELTER SURVEYS
AREA MAPS
INVENTORIES STATISTICAL ACTUAL
UPGRADABLE STRUCTURES
EXPEDIENT STRUCTURES
FACILITY UPGRADING
DISTRICT DEFINITION
EQUIPMENT
OPERATING PERSONNEL
P.O.L.
Number
Number
Access Roads
Type & Size
Skill
Quantity
Location
Location
Sanitary Facilities
MATERIAL SOURCES
Number
Number
Location
Shielding Material
Shielding Material
Other
EQUIPMENT MANAGER SUPERVISORY CADRE
Location
Location
Fuel Trucks
TASK REQUIREMENTS
RESOURCES
MATCHING AVAILABLE RESOURCES TO TASK REQUIREMENTS

Figure 18

and some steps, such as making shelter surveys or equipment inventories, may overlap or be completed in conjunction with other planning functions. This section of the report discusses planning procedures for utilizing equipment in Host County, U.S.A. It considers an example situation as well as possible variations which may be applicable in other areas.

4.2 CONTINGENCY PLANNING - SURVEYS

For the hypothetical example considered, it is assumed that Crisis Relocation Planning has been completed for a geographical area including Host County and Risk City which are about 100 miles apart. This planning, which is basically described in Ref. 1 and 2, calls for the relocation of 40,000 people from Risk City to various small Host County communities which have a combined population of about 20,000. Due to the rural nature of the area, determined Reception Care (R/C) Districts were established to coincide with the small individual communities. A map of Host County is shown in Figure 9.

The Host County planner, based on requirements of the CRP, has determined that adequate congregate care, feeding and other facilities are available. However, there are no existing structures suitable for shelter purposes, therefore, it will be necessary to provide 60,000 shelter spaces throughout his area. These findings were based on results of various surveys made by the planner and his staff. The surveys also showed that approximately 57,000 shelter spaces could be provided by upgrading structures with the remaining 3,000 being provided in expedient type shelters. Survey results are summarized on Figure 9.

The above is a very brief summary of what could be an extensive planning effort on the part of civil defense and local authorities. It provides the basis for determining effective utilization of construction equipment considered in this report. Host area districts, zones or sections used in analyzing equipment requirements do not have to be the same as the R/C districts. They should be determined on basis of reasonable apportionment of tasks, availability of shielding material, etc.

If several hundred thousand evacuees were to be relocated in a fairly high density host area, the determination and tabulation of shelter requirements would be considerably more complex than indicated on Figure 9. Existing structures might be such as to provide adequate shelter space for a good percent of the population or it may be necessary to provide a large number of expedient type shelters. Procedures and complexities of making shelter surveys are discussed in other reports and briefly in Section 1 of this report. Computer programs are available which could facilitate the process. (See Ref 1, Section 7.) An example page of a host area survey printout is reproduced here as Figure 19. It lists estimated quantity of shielding material needed (Soil Reqd. Column) to upgrade individual structures and gives an indication of the availability of shielding material (Avail Matls-Column). This or similar type of data is necessary in determining equipment utilization.

The survey printout covers approximately a 6 mile square area (based on coordinates) and shows that approximately 13,600 shelter spaces can be provided within existing structures. An

1974 DCPA HOST AREA SURVEY DATA — AS OF 11/22/74

SL	NAME AND ADDRESS	CRP NO.	COORDINATES LAT,	LONG,	NSS	BASE USE CODE	CONG CAP	SHELTER CAP EXIST	VENT	PUMP	SOIL AVAIL REQD	MTLS
61S8	MOUNTAIN TELL + TELL 814 MACON	61S80101C	382636	1051413	2	2 44	111	0	300	0	241	A
61S8	FLORENCE OFC BLDG 600 N PIKES PEAK	61S80102C	382355	1050700	2	2 44	21	0	0	0	0	A
61S8	CELLHOUSE NO 3 COLO ST PEN W MAIN	61S80122C	382615	1051455	1	1 46	700	900	0	0	0	A
61S8	MAIN DIN RM CHAPEL-KITCHEN COL ST	61S80123C	382615	1051455	1	1 46	790	1400	0	350	0	A
61S8	COLO STATE PEN WAREHOUSE W MAIN	61S80124C	382615	1051455	1	1 54	590	195	0	365	0	A
61S8	WASHINGTON SCH PART C1 9TH ST	61S80125C	382654	1051416	1	1 21	592	130	1100	0	190	A
61S8	MUNICIPAL BLD 6TH + RIVER CANON	61S80126C	382625	1051316	1	1 45	185	205	0	0	0	A
61S8	FREMONT CO COURT HOUSE 625 MACON	61S80127C	382633	1051419	1	1 51	660	825	0	0	0	B
61S8	U S POST OFFICE 505 MACON AV	61S80128C	382630	1051455	1	1 45	275	630	0	0	0	C
61S8	ST SCHOLASTICA ACADEMY 615 PIKE	61S80129C	382650	1051429	1	1 12	791	1375	0	0	0	A
61S8	FREMONT OFFICE BLD 5TH + MACON	61S80130C	382629	1051420	1	1 51	500	730	0	0	0	A
61S8	JR HIGH SCHOOL 1201 MAIN ST	61S80131C	382644	1051351	1	1 22	2	840	0	0	0	A
61S8	ABBEY SCH MONASTERY CHAPEL E HW 50	61S80132C	382656	1051201	1	1 51	850	1840	0	0	0	A
61S8	FREDRICKSON-BROWN 100 W MAIN	61S80133C	382320	1050700	1	1 51	100	55	0	145	0	C
61S8	US POST OFFICE W 2ND + PIKES PEAK	61S80134C	382327	1050702	1	1 45	180	345	0	0	0	A
61S8	GRAND LODGE IOOF 1020 N 15TH	61S80147C	382720	1051332	1	1 11	162	180	0	0	0	B
61S8	GRAND LODGE IOOF 1022 N 15TH ST	61S80148C	382720	1051331	1	1 43	30	65	0	0	0	B
61S8	POTATOE CELLAR COL STATE PEN MED	61S80162C	382530	1051000	1	1 54	42	170	0	0	0	A
61S8	IOOF RESIDENCE BLDG 1020 N 15TH	61S80163C	382720	1051332	1	1 11	280	690	0	0	0	B
61S8	GRAND LODGE IOOF POTATO CELLAR	61S80164C	382720	1051331	1	1 54	16	45	0	0	0	B
61S8	SLAUGHTER HOUSE COL STATE PEN MED	61S80180C	382520	1051000	1	1 46	375	320	0	0	0	A
61S8	HOUSING UNIT 1 + 2 COL STATE PEN	61S80181C	382255	1050910	1	2 46	650	740	290	0	530	A
61S8	DORMITORY COL STATE PEN MED SEC	61S80182C	382520	1050935	1	2 46	775	670	0	0	0	A
61S8	WOMENS HOUSING UNIT B COL STATE PE	61S80183C	382625	1051025	1	1 46	320	190	0	0	0	B
61S8	ROYAL GORGE MANOR 1122 N 15TH ST	61S80184C	382721	1051335	1	1 11	2545	625	0	90	0	B
61S8	CANON CITY FIRE DEPT 330 RIVER ST	61S80186C	382620	1051430	1	1 43	350	70	0	0	0	C
61S8	STATE ARMORY 110 MAIN ST	61S80187C	382617	1051441	1	1 47	249	85	225	0	41	A
61S8	CANON FLORAL 111 MAIN CANON CITY C	61S80191C	382619	1051441	2	2 53	24	0	94	0	112	A
61S8	MACS AUTO SUPPLY 224 MAIN ST	61S80192C	382620	1051434	2	2 53	67	0	265	0	196	A
61S8	WHOLESALE GROCERY CO 310 MAIN ST C	61S80193C	382622	1051422	2	2 54	135	0	0	0	0	A
61S8	WAXON LOCK + KEY SERV 328 E MAIN	61S80194C	382623	1051419	1	1 53	75	75	0	0	0	A
61S8	THE ASSOCIATES 332 E MAIN ST	61S80195C	382623	1051419	2	1 55	118	0	95	0	6	A
61S8	WESTERN WEAR 402 MAIN	61S80196C	382624	1051430	1	1 53	65	80	0	0	0	A
61S8	MERRIAMS PLUMBING 404 MAIN	61S80197C	382624	1051427	1	1 53	83	45	0	0	6	B
61S8	VACANT BLDG 408 MAIN	61S80198C	382624	1051427	2	1 53	85	0	170	0	39	B
61S8	G + F PLUMBING 418 MAIN	61S80200C	382624	1051426	2	1 53	100	0	0	0	0	B
61S8	JUNIOR TOWNE 422 MAIN	61S80201C	382624	1057425	2	2 53	85	0	170	0	59	B
61S8	BECKER TYPEWRITER 424 MAIN	61S80202C	382625	1051425	1	1 53	51	25	0	0	0	B
61S6	MODE-O-DAY/WINDOW WORLD 426-428 MA	61S80203C	382625	1051425	1	1 53	124	55	0	0	0	B
61S8	BEN FRANKLIN STORE 502 MAIN	61S80204C	382626	1051423	1	1 53	290	290	0	110	0	B
61S8	PURRAGE BLDG 508 MAIN ST	61S80205C	382627	1051422	2	2 53	90	0	0	0	0	C
61S8	J C PENNY CO 510 MAIN	61S80206C	382626	1051421	2	1 53	215	0	272	0	32	C
61S8	FELTER BLD 520 MAIN	61S80207C	382627	1051419	2	1 53	125	0	100	0	8	A
61S8	MASTER PRINTERS 306 MAIN CANON C C	61S80208C	382621	1051422	2	2 54	64	0	190	0	59	A
61S8	THOMAS S HDW FURN 410-416 MAIN	61S80209C	382624	1051426	2	2 53	832	0	320	0	116	B
61S8	J M MCDONALD CO 602 MAIN ST	61S80210C	382755	1050917	2	1 53	220	0	0	0	0	B
61S8	MAJESTIC SAVINGS 618 MAIN ST	61S80212C	382630	1051415	2	2 55	90	0	0	0	0	B
61S8	SKYLINE MOTEL 219 MAIN ST	61S80213C	382622	1051437	2	1 11	50	0	70	0	69	B
61S8	WAREHOUSE 223 MAIN ST	61S80214C	382621	1051434	2	2 54	50	0	0	0	0	B
61S8	GHNELAS AUTO SVC 231 MAIN ST	61S80215C	382622	1051434	2	2 86	90	0	0	0	0	B

Figure 19 - EXAMPLE PAGE OF HOST AREA SURVEY PRINTOUT

additional 3,660 spaces could be provided by upgrading. The estimated quantity of shielding required for these additional spaces is 1,700 cu yd which is less than 1/2 cu yd per upgradable shelter space. Before making the survey the planner would decide whether to estimate the quantity of shielding material for each structure; use an average such as 1 cu yd per shelter space or use guidelines such as shown as Table 2. This decision would probably depend on manpower available to make the survey and the amount of detail which the planner thinks necessary to develop a workable equipment utilization plan.

Regardless of what procedure or format is used, the shelter survey should provide the following information:

1. Identification and location of structures to be upgraded.
2. Quantity of shielding material for each structure.
3. Source of shielding material.
4. Need and location of expedient shelters.

Location of upgradable structures, expedient shelters and material sources should be marked on a large map of the area. Using this map and his overall evaluation of tasks to be accomplished, the planner would divide his area into various sections, probably on the basis of comparable quantities of shielding material required in each (actual number of upgradable structures could vary significantly). The material source for each area would be identified. Each area would be considered as a task for subsequent planning of equipment utilization. This grouping is done for two reasons, first it would not be practical to con-

sider each and every structure, and secondly, if the plan was actually initiated, the movement of trucks and equipment would have to be directed and monitored by supervisory personnel on the basis of actual requirements and work progress, which would not necessarily coincide with determinations based on pre-event planning procedures.

If the total amount of equipment is limited with respect to task requirements, the planner may have to set priorities for different sections depending on total number of shelter spaces to be provided. For instance, zones A and B might each require the handling of 10,000 cu yd of material. Upgraded structures in zone A might provide 15,000 shelter spaces, while those in zone B only 8,000 spaces. The planner would probably direct his equipment to zone A first and then to zone B.

Equipment tasks for Host County are related to the various individual communities, with Main Town being divided into five sections or zones and Second Town into two zones. After a building by building survey is completed, a list of actual tasks for Host County would be prepared as shown in Table 17. Tasks and other information have been determined in accordance with data of Tables 1 and 2 and Figures 9 and 10. Columns 1 and 2 of Table 17 show shelter location by town and zone. Columns 3 and 4 indicate the number of buildings and type of shielding task required for each. Column 5 summarizes number of shelter spaces to be provided. Columns 6 and 7 designate the most appropriate borrow pit from the Borrow Area Locator Map, Figure 10, and its distance from the shelters. Columns 8 thru 10 quantifies excav-

"HOST COUNTY" FALLOUT SHELTER SUMMARY

ZONE	LOCATION	SHELTER BUILDINGS			BORROW AREA		EXCAVATE & HAUL SOIL			PLACE SOIL	
		NO. OF BLDGS.	TASK TYPE	NO. SHELTER SPACES	SOURCE CODE	AVG. DISTANCE	THEO. QUAN.(CY)	ACTUAL INCL. WASTE	TRUCK CY.MILES	BY HAND	BY EQUIP.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
A	MAIN TOWN: Downtown Area	22-M*	F	5,000	47T5-B	2.5	3,000	3,300	8,300	1,300	2,000
		12-W	G	3,500	47T5-A	2.0	2,100	2,300	4,600	1,800	500
		8-W	D	2,500	47T5-A	2.0	4,000	4,400	8,800	1,300	3,100
B	N.E. Area (For expedient shelters see below)	9-W	D	4,000	47T5-B	1.0	6,400	7,000	7,000	2,100	4,900
		6-M	E	2,000	47T5-B	0.5	800	900	500	500	400
C	N.W. Area	8-W	D	2,500	47T5-A	1.0	4,000	4,400	4,400	1,300	3,100
		4-M	E	1,500	47T5-A	0.8	600	700	600	400	300
D	S.E. Area	14-W	D	4,500	47T5-C	1.0	7,200	7,900	7,900	2,400	5,500
		7-W	I	1,500	On Site	-	1,000	1,100	-	700	400
E	S.W. Area	6-W	D	1,500	47T5-C	0.5	2,400	2,600	1,300	800	1,800
		8-W	H	1,500	On Site	-	1,000	1,100	-	300	800
F	SECOND TOWN: N. of U.S. 7	26-W	F	6,000	47T5-F	1.0	7,200	7,900	7,900	3,200	4,700
		14-M	G	3,000	47T5-F	1.5	1,200	1,300	2,000	1,000	300
G	S. of U.S. 7	12-W	D	4,000	47T5-G	1.5	6,400	7,000	10,500	2,100	4,900
		4-M	E	1,000	47T5-G	2.0	400	500	1,000	300	200
H	C-TOWN (All)	13-W	F	4,000	47T5-H	1.0	4,800	5,300	5,300	2,100	3,200
		6-M	I	2,000	On Site	-	800	900	-	500	400
I	D-TOWN (All)	10-W	F	3,500	47T5-K	0.8	4,200	4,600	3,700	1,800	2,800
		7-M	H	1,500	On Site	-	1,500	1,700	-	500	1,200
J	E-TOWN (All)	6-W	D	1,000	47T5-L	0.5	1,600	1,800	900	500	1,300
		4-M	E	1,000	47T5-L	0.6	400	500	300	300	200
Sub Total Upgraded Shelters		206	-	57,000			61,000 (On Site 4,800) (Off Site 62,400)	67,200	75,000 (On Site 2,800) (Off Site 39,200)	25,200	42,000
B	Expedient Shelters		L	3,000	On Site	-	6,000	6,600	-	6,600	-
TOTAL REQUIREMENTS		206	-	60,000	-	-	67,000	73,800		31,800	42,000

*M = Masonry, W = Wood

Table 17

ation and hauling tasks, and 11 and 12 the placing tasks. Column 8 is an estimate of actual shielding material needed and 9 is the same with a 10% allowance for waste. Each is rounded off to the nearest 100 cu yd. This makes calculation easier, and the degree of accuracy used in estimating does not justify greater precision. Column 10, the truck cu yd-miles is calculated by multiplying column 9 by column 7. Columns 11 and 12 are calculated by multiplying the total volume in column 9 by the percentages shown for hand and equipment placing found in Table 2 with respect to task codes given in column 4. These calculations idicate that the quantity to be placed by hand is slightly less than the 40% assumed for average conditions.

After the tasks required for the Host County are determined, it is necessary to know how much equipment is available to perform these tasks.

4.3 CONTINGENCY PLANNING - INVENTORIES

Section 3 outlines various inventorying procedures which can be used to determine availability of equipment and other resources within CRP areas. It would be desirable to make a fairly accurate inventory of needed resources using forms and procedures as given in Section 3. In all likelihood, these inventories would also be used in planning other CRP functions. They should be updated periodically to account for movement or changes of resources within the area. The type and number of equipment units should be noted at their respective serial yard locations on the map of the area.

Comparing equipment locations with task locations will give an indication of potential equipment transfers within the host area zones or between risk and host areas. This of course, would also depend on the size of tasks and productivity of the equipment, which is discussed later. Availability and location of operating personnel and P.O.L. supplies could be identified on the map or listed in accordance with task areas or other locator methods.

In lieu of an actual inventory, the planner could make an approximate evaluation of equipment availability by using statistical averages as discussed in Section 3. This fairly simple approach would indicate whether or not the potential equipment resource would be capable of completing necessary tasks. If not, plans for transferring equipment from other areas should be studied. Even if statistical averages indicate that ample equipment would be available, it would be necessary to establish reasonable locator designations for final planning.

For the example situation, equipment units available in Host County and Risk City were determined on the basis of statistical averages in accordance with discussion of paragraph 3.2. Results are shown by equipment codes on Table 16. Equipment units shown for Risk City are based on number (40,000) of evacuees to be located in Host County. Remaining Risk City equipment would be considered with respect to the relocation of people to other host areas. The number of dump trucks has been arbitrarily assigned on the basis of what would typically be available with respect to the number of excavating units located in the county.

Distribution of equipment within Host County is shown on Table 18. A serial locator number has been assigned to individual equipment owners. Results of equipment surveys and inventories for Host County are shown on the area map of Figure 16.

4.4 CONTINGENCY PLANNING - SUPERVISION

Having completed various surveys and inventories, the next step is to establish supervisory control for completing necessary tasks. This would include such functions as setting priorities, matching equipment productivity with requirements, transferring equipment if required, assigning equipment and other resources to specific tasks, direction and control during actual accomplishments of tasks, establishing communications, etc. As mentioned, some of these functions may be integrated with the overall CRP activities. Depending on the size of the study area and magnitude of tasks, this function may be fulfilled by the individual planner or it may require a fairly large staff of people. The planner or planning staff supervisor would be responsible not only for directing the use of construction equipment, but also for coordination with other aspects of CRP such as movement of evacuees, transportation of supplies and equipment, allocation of fuel, availability of laborers, etc.

4.5 EQUIPMENT UTILITATION - GENERAL OVERVIEW APPROACH

Scheduling and use of equipment for upgrading and expedient shelter tasks is determined by matching productivity of available equipment with task requirements and time. The procedure would be basically the same whether considering an individual structure requiring 200 yards of shielding or a group of tasks

KEY EQUIPMENT INVENTORY - "HOST COUNTY"									
OWNER SERIAL	LOCATION	DOZERS	FRONT END LOADERS		EXCAVATORS		DUMP TRUCKS		
		CRAWLER	WHEEL*	CRAWLER	SHOVEL	BACKHOE	5 CY	10 CY	20 CY
47T5-1	Main Town	1-288	2-163	1-160D	1-262	-	-	4	4
47T5-2	Main Town	1-284	1-167	1-162	-	-	-	2	2
47T5-3	Main Town	1-280B	1-161C*	1-160A	-	1-022	2	-	-
47T5-4	Main Town	1-280D 1-280A	1-165 1-161D	-	-	-	4	-	-
47T5-5	Second Town	1-280C	1-161B*	1-164	1-260	-	2	-	2
47T5-6	Second Town	1-286	1-161C* 1-169	1-160C 1-160B	-	1-020	2	4	2
47T5-7	C-Town		1-161B*	-	-	-	1	-	-
47T5-8	C-Town	1-282	1-161B	1-160A	-	-	2	-	-
47T5-9	D-Town	1-280B	1-161D*	1-160B	-	-	3	-	-
47T5-10	E-Town	1-280A	1-161A*	-	-	-	2	-	-
47T5-11	Rte.216, near Int. Rte. 215	1-280C	1-161A*	-	-	-	-	4	-
47T5-12	Rte.216, 4 mi W. of D-Town	-	1-161A*	-	-	-	2	1	-

*Following Code No. indicates Front end loader/backhoe combination.

Table 18

requiring a total of 10,000 cu yd. In the case of larger volumes of work, the process can be performed in two stages each of which is illustrated here. To obtain an overall view of the capability of performing required tasks, they should be divided on the basis of priority with tentative assignments of equipment made to high priority tasks such as borrow pit excavation and truck loading. The placing tasks can then be compared to the remaining equipment on the basis of average production rates to see if additional equipment is required from the risk area. The second stage would involve individual unit assignments by matching units to tasks on a local level with a minimum of shifting from one zone to another. An example of how this would be accomplished can be seen by considering the overall task requirement for Host County.

Table 17 shows a total of 73,800 cu yds to be excavated in Host County, slightly higher than the 1 cu yd per space assumed earlier. The total includes 4,800 cu yds of on-site material and 6,600 cu yds for expedient shelters; leaving 62,400 cu yds to be excavated at borrow pits and hauled to shelter sites. It should be noted that each excavation quantity includes a 10% waste allowance, as it is virtually impossible to transport, stockpile and rehandle material without losses. If properly organized, the work of upgrading building shelters could begin right after the crisis declaration using equipment available in the county. In the first few hours, movement of equipment within the county can be accomplished without hindering evacuees. Excavating and hauling material to upgradable structures can be

started by equipment operators within the county with a minimum number of helpers. Even placing of wall shielding could begin leaving the hand placing of roof shielding till the shelter occupants have arrived.

It is assumed that work will proceed for the three day crisis period on the basis of two 10 hour shifts per day using emergency lighting as required. If sufficient equipment operators are available, it would be possible to work three 8 hour shifts, but since it will be necessary to fuel, service and move the equipment, considering twenty hours of work per day is more realistic than anticipating a full twenty-four hours of production. This approximates the 20% lost time previously mentioned.

Of the two backhoes available in Host County, one (Code 022) is capable of excavating the 6,600 cu yd for expedient shelters in under three days (see Table 7). The other backhoe and two shovels can be used for excavating and loading at borrow pits. In sixty hours, these three units can excavate and load 18,600 cu yd as shown on the production summary sheet of Table 12. To excavate and load the remaining 43,800 cu yd in sixty hours requires equipment capacity of 730 cu yd per hour. For maximum efficiency, large dozers and loaders should be used for excavating and loading with smaller units used for placing shielding. Using Table 7 as a guide, and reviewing the dozers and loaders available, it is possible to excavate with two dozers (one each of Codes 288 and 286) and load with five loaders (one each of Codes 169, 167 and 165 and two each of Code 163). This leaves a total of twenty-seven smaller dozers and

loaders to excavate on-site material and place the wall shielding material.

From Table 16, it can be seen that twenty, 5 yard dump trucks, fifteen 10 yard dump trucks and ten 20 yard dump trucks are available to haul 62,400 cu yd. From Table 17, this represents 75,000 cu yd-miles of hauling or an average haul distance of 1.20 miles. Using an average loading rate of 200 cu yd per hour, per loading unit, Figure 13 shows the twenty, 5 yard trucks capable of hauling 400 cu yds per hour. The fifteen, 10 yard trucks can haul about 525 cu yds per hour, and the ten 20 yard trucks about 600 cu yds per hour. The combined total haulage of 1,525 cu yds per hour can complete the hauling required in 41 hours. If there had been insufficient trucks available, additional dump trucks could be brought in from the risk area, but would not be available for the full three days because of moving time and driver orientation. Unusually long haul distances could also reduce the amount of haulage capability. Doubling the average haul distance in this case would increase the time required from 41 hours to 58 hours and tripling it would require 74 hours, making it necessary to acquire additional trucks from Risk City.

For the purpose of the equipment summary, the remaining units for placing shielding can be considered as a group by using average production rates. Individual detailed assignments can be worked out after determining if the total number of units is adequate. The excavation and placing of on-site material (Tasks H - K) requires handling 4,800 cu yds in 60 hours. Three

units, averaging 30 cu yds per hour per unit, would be sufficient for this work, however, since four sites are involved, some interim redeployment would be required. If sufficient units are available it might be preferable to start this work with four units.

There remains 39,200 cu yds of wall shielding to be placed with equipment, 25,200 cu yds of roof or floor shielding to be placed by hand, plus 6,600 cu yds at the expedient shelters, which is considered separately. The wall shielding (Tasks D - G) average about 50 cu yds per hour, per unit, or 1,150 cu yds per hour for the remaining twenty-three units. At this rate it would require about 34 working hours to place all wall shielding. This means that the equipment available would be adequate, if properly used and supervised, to perform the tasks required without importing equipment.

The relatively low roof shielding over the trench type expedient shelters could be placed by either machine or by hand. Because of the apparent sufficiency of equipment, this could be done by loaders after constructing the structural frames by hand. In areas with less equipment available, hand labor would be used.

The calculations described above are summarized on Table 19. The planner should prepare a similar tabulation to insure that all equipment units are accounted for, and that all tasks are considered in their proper priority. The table is set up in two parts. On the left is listed known data; on the right the calculated results, which can show: in cu yds the portion of

COMPLETING HOST COUNTY TASKS (CALCULATIONS)									
TASKS	REFERENCE TABLE(T) FIGURE(F)	DATA GIVEN				CALCULATED RESULTS			
		QUANTITY (CY)	NO.OF HOURS	EQUIPMENT		QUANTITY (CY)	NO.OF HOURS	EQUIPMENT	
				CODE	CY/HR			CODE	CY/HR
L	T12	6,600	-	1-022	140	-	47*	-	-
A + B	T12 T-16	62,400	60	1-020 1-260 1-262	310	18,600**	-	-	-
A		43,800	60	-	730	-	-	1-288 1-286	520 400 920*
B		43,800	60	-	730	-	-	1-169 1-167 1-165 2-163	185 185 185 370 925*
C	T-17 F13	62,400	60	20-5 cy 15-10cy 10-20cy	400 525 600	-	41*	-	-
H - K	T12	4,800	-	4-AVG SMALL UNITS	120	-	40*	-	-
D - G	T12	39,200	-	23-AVG SMALL UNITS	1150	-	34*	-	-

*Sufficient to complete tasks. **Not sufficient to complete tasks.

Table 19

task performed, the number of hours to complete the task, or the combined production rate of proposed equipment to complete a task.

As an example, completing tasks A and B, excavating and loading, involved several calculations. The backhoe and two shovels have a combined production rate of 310 cu yds/hr, capable of handling only 18,600 cu yds in 60 hours. This leaves 43,800 cu yds or 730 cu yds/hr for 60 hours. The calculations at the right show that the two dozers and five loaders can excavate 920 cu yds/hr and load 925 cu yds/hr respectively. Although this is a satisfactory solution for the overall view, location of pit areas and equipment will dictate other considerations for individual assignments as will be seen shortly. It is still important to go through this sort of calculation for an initial appraisal of total capability.

4.6 EQUIPMENT UTILIZATION - DETAILED UNIT ASSIGNMENTS

The preceeding example is sufficient to illustrate general procedures for determining whether available equipment can be reasonably expected to perform tasks required. For an emergency period, more detailed scheduling and coordinating will be required to avoid inefficiencies and insure that all tasks are completed. The basic procedures would be the same except that each individual piece of equipment must be scheduled for particular tasks using its anticipated rates of production instead of overall averages.

Operators at borrow pits must know how much they are to excavate and must maintain records of actual truckloads deliv-

ered. Truck drivers must be assigned to a borrow pit and be told where to dump their load. Much of this can be done at the pit by a coordinating foreman, or by flagmen stationed throughout the task area, but must be planned ahead of time. Placing equipment should be assigned to shelter sites near their yard location if possible, to keep highway travel to a minimum. Assignments made prior to performance will be tentative and periodic checks on actual progress may indicate necessary changes in assignments to keep all units operating efficiently.

If sufficient equipment exists to complete all tasks as in Host County, excavation and loading should begin in each town as soon as possible so that the placing equipment can start work. When the excavation is complete these units can be available for redeployment. Also the planner must remember that the placing equipment cannot complete its work any faster than the rate of supply of earth from the borrow pit.

Table 20 shows one of many possible combinations of detailed equipment assignments for Host County. Units with the same code have been given an individual number suffix following the code number so it can be more easily identified. The tasks are taken from Table 17, the equipment and locations from Table 18, and the individual production rates for various tasks from Table 12. The individual units initially available are listed in the first column. A use code designation of one letter has been added to indicate what the unit is assigned to. This is useful when working on the form to see which units are still available for assignment.

DETAILED EQUIPMENT ASSIGNMENTS

TOWN AND AVAILABLE EQUIPMENT		REQUIRED TASKS				TRANSFER FROM ZONE	EQUIPMENT ASSIGNMENTS				TRANSFER TO ZONE
		TYPE	ZONE	TASK CODE	QUAN (CY)		EQUIP CODE	HOURLY PROD	TOTAL PROD	HOURS USED/REM	
MAINTOWN	Use	EXCAVATE	A-E	A	33,500	-	262#1	160	9,600	60/-	N.A.
						-	288#1	520	23.900	46/14	-
262#1	E										
022#1	P	LOAD	A-E	B	33,500	-	262#1	160	9,600	(above)	N.A.
288#1	E					-	167#1	185	11,100	60/-	N.A.
284#1	X					-	165#1	185	11,100	60/-	N.A.
280D#1	S					-	163#1	185	1,700	10/50	-
280B#1	S										
280A#1	S	EXPED. SHELTER	B	L	6,600	-	022#1	140	6,600	48/12	-
167#1	L										
165#1	L										
163#1	L	ON SITE	D	I	1,100	-	163#2	75	1,100	15/45	-
163#2	O										
161D#1	S		E	H	1,100	-	161C#1	50	1,100	22/38	D
161C#1	O										
162#1	S	PLACING	A	F	2,000	-	280D#1	50	2,000	40/20	A
160D#1	S	SHIELDING		G	500	A	280D#1	50	500	10/10	D
160A#1	S	ONLY		D	3,100	-	160D#1	70	3,100	45/15	B
Use Code:			B	D	4,900	-	161D#1	90	4,900	55/5	-
E - excavate				E	300	A(-2)	160D#1	65	300	5/8	-
L - load											
P - expedient shelters			C	D	3,100	-	280B#1	45	2,700	60/-	N.A.
						-	160A#1	25	400	16/44	D
O - on site shielding				E	400	D	160A#1	22	400	19/25	-
S - shielding only			D	D	5,500	-	162#1	90	5,400	60/-	N.A.
						E(-2)	161C#1	75	100	2/34	-
T - transferred											
X - not used			E	D	1,800	-	280A#1	35	1,800	52/8	-

Note: (-2) in "Transfer From Zone" column signifies two hours allowed for interzone transfer.

Table 20

DETAILED EQUIPMENT ASSIGNMENTS										
TOWN AND AVAILABLE EQUIPMENT		REQUIRED TASKS				TRANSFER FROM ZONE	EQUIPMENT ASSIGNMENTS				TRANSFER TO ZONE
		TYPE	ZONE	TASK CODE	QUAN (CY)		EQUIP CODE	HOURLY PROD	TOTAL PROD	HOURS USED/REM	
SECOND TOWN	Use	EXCAVATE	F-G	A	16,700	-	260#1	80	4,800	60/-	N.A.
						-	020#1	70	4,200	60/-	N.A.
260#1	E					-	286#1	400	7,700	20/40	-
020#1	E										
286#1	E	LOAD	F-G	B	16,700	-	260#1	80	4,800	(above)	N.A.
280C#1	X					-	020#1	70	4,200	(above)	N.A.
169#1	L					-	169#1	185	7,700	42/18	-
161C#2	S										
161B#1	X	PLACING	F	F	4,700	-	164#1	90	4,700	53/7	F
164#1	S	SHIELDING		G	300	F	164#1	80	300	4/3	-
160C#1	S	ONLY									
160B#1	X		G	D	4,900	-	161C#2	75	4,500	60/-	N.A.
						-	160C#1	55	400	8/52	G
				E	200	G	160C#1	50	200	4/48	-
TOWN - C	Use	EXCAVATE	H	A	5,300	-	282#1	230	5,300	23/37	H
282#1	E,S	LOAD	H	B	5,300	-	161B#2	70	4,200	60/-	N.A.
161B#2	L					-	161B#3	70	1,100	16/44	H
161B#3	L,S										
160A#2	O	ON SITE	H	I	900	-	160A#2	15	900	60/-	N.A.
		PLACING	H	F	3,200	H	282#1	55	2,000	37/-	N.A.
		SHIELDING				H	161B#3	45	1,200	27/17	-
TOWN - D	Use	EXCAVATE	I	A	4,600	-	280B#2	85	4,600	55/5	-
280B#2	E	LOAD	I	B	4,600	-	161D#2	130	4,600	36/24	I
161D#2	L,S										
161A#1	O	ON SITE	I	H	1,200	-	161A#1	24	1,200	50/10	-
160B#2	S	PLACING	I	F	2,800	-	160B#2	35	2,100	60/-	N.A.
		SHIELDING				I	161D#2	70	700	10/14	-
TOWN - E	Use	EXCAVATE	J	A	2,300	-	280C#2	110	2,300	21/39	-
280C#2	E	LOAD	J	B	2,300	-	161A#2	40	2,300	58/2	-
280A#2	S										
161A#2	L	PLACING	J	D	1,300	-	280A#2	35	1,300	38/22	J
161A#3	X	SHIELDING		E	200	J	280A#2	35	200	6/16	-

Table 20 (Continued)

The next four columns indicate the type, location and magnitude of tasks using the same order of priorities for the town as used in the general county summary. The final six columns are for matching the equipment to the tasks and for indicating movement of units from one task to another. Column 6 "Transfer from Zone", is filled in only if the unit is moved from another assignment. Original assignments in the town of origin are dashed (-). Likewise, the last column is used only when the unit is reassigned.

Column 11 "Hours - Used/Rem" should add to 60 (the total hours available) on original assignments. On reassignments they add up to the time remaining from the previous assignment except that for all inter-zone movements two hours are deducted for extra travel time. For example the unit 161C #1 is used for on-site excavation and placing in Zone E of Maintown. It uses 22 hours at 50 cu yds/hr to handle 1,100 cu yds with 38 hours remaining. Subsequently, it is reassigned to Zone E to place shielding after deducting 2 hours for travel.

Although only 2 hours of work are shown at this site it should be noted that the other unit at this site, 161D #1, is shown working for 60 hours and that 161C #1 is not further reassigned. In actual practice both units would work together on this task until complete, but it is not necessary to show this final refinement on this table. It is only necessary to show that all tasks will be completed in reasonable time. It can also be seen that 5 units are not used at all, while other units are working a full 60 hours. This could be adjusted, but is not

necessarily warrented for preliminary planning. Some units may need repair or be working in another county at the time of emergency. If extra units are actually available they can be moved to help at critical task locations. Also, some units may not perform as well as expected, while others may complete their tasks early, so some flexibility of scheduling is necessary.

Table 20 is sufficiently complete for preliminary planning as shown. It is likely however that the planner may have to go through a summary several times to arrive at this stage, due to the complexity of matching equipment to tasks. This is not wasted motion, as it helps to familiarize the planner with the planning process. It will give him a more thorough understanding of the units available and tasks required and will better enable him to make field adjustments if the time comes when the plan is actually implemented.

An assignment plan similar to Table 20 can also be made for dump trucks. While this would be simpler than the excavating and placing plan it would have to be coordinated with the loading units at each borrow pit.

It is also interesting to note the degree of accuracy of the average and detailed equipment assignments. From Table 19 it can be calculated that the 38 units available are used for an average of 40 hours each. After taking each unit individually and applying appropriate production rates for various tasks, calculations based on Table 20 show an average use of 41 hours for the 38 units. This shows that the approximate method is quite sufficient for an overall evaluation of county-wide

capability, though the detailed assignments are still necessary for final planning.

Equipment operating requirements (P.O.L., etc.) would be determined by multiplying respective hourly requirements given on Table 6 by the number of hours that each unit is used. These requirements should be increased by 20% to allow for lost time and operating inefficiencies. Labor and other resources could be approximated by following guidelines provided in paragraph 2.6.

SECTION 5

EQUIPMENT INVENTORY - FREMONT CO. COLORADO

5.1 GENERAL

Previous sections of this report have discussed various methods and procedures for determining requirements and utilizing equipment during a crisis relocation period. A prediction was made of the number of equipment units suitable for CRP tasks that would be available within typical host and risk areas. The prediction was based on statistical national averages relating units of equpment with either rural (host area) or urban (risk area) populations.

The size, population densities and geographic proximity of the hypothetical areas used in the evaluations are similar to those of Fremont County and Colorado Springs in Colorado which have been used as prototypes in previous CRP studies. Due to this similarity it is possible to make fairly accurate appraisals of the validity of equipment availability predictions made for the study example by comparison with actual conditions within a prototype area.

This section of the report describes the inventorying of equipment in Fremont County and a portion of Colorado Springs and compares results with initial predictions.

5.2 MAKING THE INVENTORY

A survey of excavating and hauling equipment needed to perform CRP tasks was made in Fremont County during June 1977. A two man study team gathered the information summarized in

Table 21 in a period of three days. The experiences gained in making the survey may be of help to the planner who must follow similar procedures in his community.

Contact was made with the part time director of Civil Preparedness in Canon City (principal City in Fremont County) through the DCPA in Denver prior to the inventory. In addition, several contractors, sand and gravel companies and trucking companies had been contacted by mail to advise them of the upcoming survey. The Director, who is also a member of the County Planning Department, was able to provide introductions to the city governments of Canon City and Florence and to the various utility companies. In addition, he provided a list of county owned equipment and a list of excavating contractors that have done work for the county. Several of the smaller contractors were not listed in the yellow pages of the phone book and might have been overlooked otherwise. Nearly all were contacted either by scheduled meetings or by phone.

Several of the one man, one equipment unit contractors could not be reached during the day. In some cases, information regarding their equipment was provided by other contractors. Most everyone contacted was very cooperative. A few were reluctant to give information until assured it would not be used for tax or promotional purposes. A local planner during a crisis period presumably would not have a problem in this respect. In general, it was found that those who had been previously contacted by mail were the most cooperative.

CONSTRUCTION EQUIPMENT INVENTORY FREMONT COUNTY, COLORADO									
OWNER	LOCATION	FRONT END LOADERS		DOZERS		SHOVELS & BACKHOES		DUMP TRUCKS	
		NO.	CODE	NO.	CODE	NO.	CODE	NO.	SIZE
COLO. STATE H'WAY DEPT.	Canon City	2 2	161A 161C	-		-		11	5 cy
FREMONT COUNTY:									
District 1	Canon City	2	161A	1	280C	-		5	5 cy
District 2	Penrose	1 1	161D 161B	1 1	282 280D	-		7	5 cy
District 3	Cotopaxi	1	163	1 1	284 280C	-		3	5 cy
District 4	Highway 9	1	161C	1 1	284 280A	-		3	5 cy
CANON CITY	Canon City	5	161A	-		3	020	10	5 cy
CITY OF FLORENCE	Florence	1	161A	-		-		3	5 cy
SOUTHERN COLO. POWER	Canon City	1	161A	-		-		1	5 cy
GREELEY GAS CO.	Canon City	1	161A	-		-		-	
PENROSE WATER DISTRICT	Penrose	1	161A	-		-		-	
CONTRACTORS (12)	Canon City	2 6 8	163 161B 161A	1 3	284 280B	-		12 11	10 cy 5 cy
CONTRACTORS (3)	Florence	2 2	163 161A	2 3	284 282	-		6	5 cy
CONTRACTORS (2)	Penrose	2	161A	-		-		1	5 cy
SAND, GRAVEL, CONC.(2)	Canon City	1 3 2	169 163 161D	1 1	284 282	1 1	022 260	5 4	10 cy 5 cy
SAND, GRAVEL, CONC.(1)	Florence	2 1	161C 161B	1	284	-		6	10 cy
TRUCKING (2)	Canon City	4	161D	1	284	1	022	39	20 cy
TOTAL		54		20		6		127	

Table 21

In order to assure as complete an inventory as possible, the study team modified their intended approach on the amount of information requested (see Section 2). It was felt that it was more important to determine the total amount of equipment than to have some owners refuse to cooperate on the basis that too much detail was requested. Some of the equipment sizes shown on the inventory list therefore are based on visual observations of the study team or a conservative guess based on company size, function, etc. In some cases, lists of equipment provided by owners included the manufacturer's name and model designation; in others, only general terms such as "loaders with backhoe" or "dozer" were used. Since most dozers were track mounted and most loaders wheel mounted, they have been designated as such in Table 21 with no attempt made to separate out track-mounted loaders. It is felt, however, that the proportion of wheel loaders in Fremont County is higher than indicated by the statistical averages.

In addition to governmental agencies, utilities and private construction companies, there is some mining and farming in Fremont County. Representatives of these industries were not contacted during the survey. A contractor from another county was completing a rather large project near Canon City at the time of the inventory. This companies' equipment, consisting of several excavating units and a number of trucks, was not included as they normally are not maintained in the county.

No large equipment rental dealers operate in Fremont County and as far as could be determined, no rented equipment from outside the county was being used.

5.3 RESULTS OF FREMONT COUNTY INVENTORY

The total number of construction equipment units in Fremont County exceeded the amount predicted through statistical averages, with more than double the number of dozers and loaders and almost triple the number of dump trucks. Either the statistical average used in making preliminary predictions are wrong or Fremont County cannot be considered typical with respect to amount of equipment available. It is unlikely that the data from the Department of Commerce is seriously in error, and even those figures that are interpolated should be reasonably close. While it is conceded that the split between "urban" and "rural" is at best an approximatation and probably varies depending on the relative sizes of the urban and rural areas and population involved, it is hard to conceive that with a national ratio of 1 unit per 770 people that a typical rural area could possess 1 unit per 280 people as in the case of Fremont County. Statistically then, a corresponding urban area could only possess 1 unit per 5200 people with a rural/urban ratio of 1:18, instead of 1:1.5.

It is more likely that Fremont County cannot be considered average for the country. At least one person contacted in Colorado Springs stated that Fremont County probably has more construction equipment than surrounding counties. A veteran contractor stated that there were only three excavating contractors in the county twenty-five years ago but there are now at least 17, indicating considerable growth of this industry in the county.

In other respects there are some correlations that can be drawn between the Fremont County inventory and the statistical averages of Table 15. The ratios of loaders to dozers agree within a few percentage points. The ratio of shovels/backhoes to loader/dozers is slightly lower in Table 21 while that of dump trucks to loaders/dozers is higher in Table 21, by 30%. Except that the number of all types of equipment is more than expected, the relative mix of equipment is not out of line with expectations. One exception is the large number of 20 yard dump trucks found. Since two large companies account for most of these trucks, it is possible that this is an unusual situation and that surrounding counties might lower the average.

5.4 PARTIAL INVENTORY - COLORADO SPRINGS

Although a complete inventory of construction equipment was not made for Colorado Springs, sufficient information was acquired to assess the effort that would be needed for a full survey. With the cooperation of the Civil Preparedness Agency in Colorado Springs, the team was able to accomplish quite a bit in two days. The Operations Officer provided contacts, and in some cases, introduced the team to State, County and City officials who provided data on their equipment. As the utilities in Colorado Springs are owned by the City, this equipment was also included. The summary of this data is given in Table 22. Although the inventory is only partial with respect to the total city, it is complete for that segment comprising government agencies and utilities. It is interesting to note that if the loader/dozer units owned by government and utilities in

CONSTRUCTION EQUIPMENT INVENTORY

COLORADO SPRINGS, COLORADO (PARTIAL)

GOVERNMENT AGENCIES AND UTILITIES

OWNER	LOCATION	FRONT END LOADERS		DOZERS		SHOVELS & BACKHOES		DUMP TRUCKS	
		NO.	CODE	NO.	CODE	NO.	CODE	NO.	SIZE
COLO. STATE H'WAY DEPT.	Colo. Springs	1	163	-		-		12	10 cy
		4	161D					10	5 cy
EL PASO COUNTY	" "	2	165	4	280C	3	020	11	10 cy
		3	163	1	280A			21	5 cy
		1	161D						
CITY OF COLORADO SPRINGS									
GENERAL	" "	9	163	2	284	1	020	47	5 cy
				1	280A	1	260	1	20 cy
PIKES PEAK H'WAY	" "	2	163	1	286	1	020	6	5 cy
ELECTRIC DIVISION	" "	1	161D	4	280C	1	020	1	5 cy
		1	161B						
		3	161A						
GAS DIVISION	" "	8	161A	3	280A	-		8	5 cy
WATER DIVISION	" "	2	163	2	282	2	020	10	5 cy
		9	161B	1	280C	1	260		
WASTE WATER DIV.	" "	1	161B	1	280C	-		7	5 cy
TOTAL		47		20		10		134	

Table 22

Colorado Springs is in the same proportion (about 1/3) as determined for Fremont County, then the total number of equipment units in Colorado Springs would be close to the number predicted by national averages.

Although the process of making a complete inventory of Colorado Springs would be more involved and time consuming than in Fremont County, the cooperation received from the Civil Preparedness and other agencies was very encouraging. It is expected that additional help would be received from the private sector. In addition to the government agencies contacted, some time was spent with a local construction equipment supplier. He discussed the statistical average prediction of units for Colorado Springs and felt that it was a reasonable number for the area. He also agreed to supply a list of contractor customers to contact. Since all contractors buy spare parts from equipment suppliers, this is an important additional contact in urban areas for the planner to remember.

The ratio of dozer to loader units from Table 22 is again close to prediction, while that of shovels/backhoes and dump trucks is higher by 50% or more.

5.5 CONCLUSIONS

Fremont County has more than double the amount of excavation equipment predicted and three times the number of dump trucks. With respect to predictions based on statistical averages Fremont County does not appear to be typical of potential host areas. The planner should consider that for every area such as Fremont County that has more than the

average amount of equipment, there are other areas with less than average. In some of these areas there will not be enough local equipment to complete required tasks without outside assistance.

The preliminary appraisal of equipment units in Colorado Springs seems fairly well in line with statistical predictions.

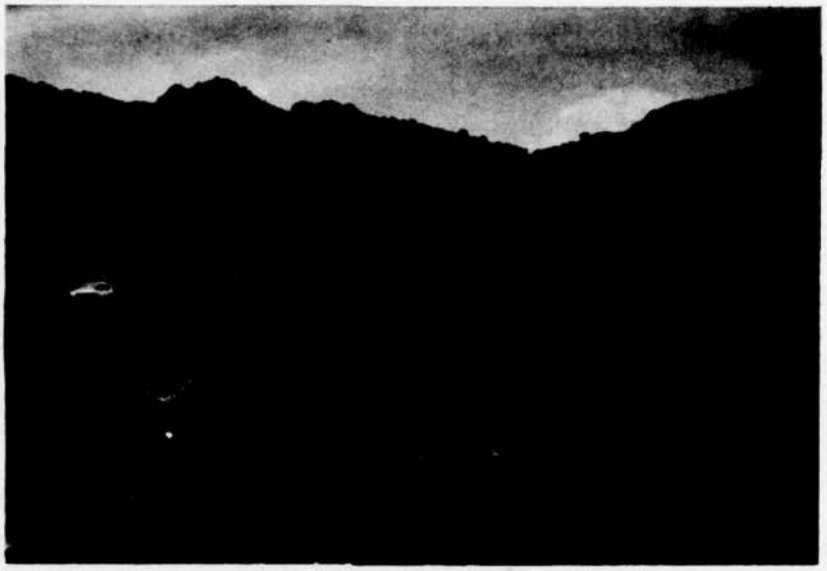
If sufficient additional data could be acquired, the method of predicting available equipment could be refined to reflect local conditions instead of national averages. Geographical location, construction industry activity and local economy all affect these statistics. Relative population densities of host and risk areas also influence equipment usage and availability.

For general interest, several photographs of Fremont County are included as Figure 20. They show potential upgradable structures and expedient shelter sites; digging and loading operations, equipment units and other physical aspects of a rural host area which would be appraised by the planner and which have been discussed generally in this report.

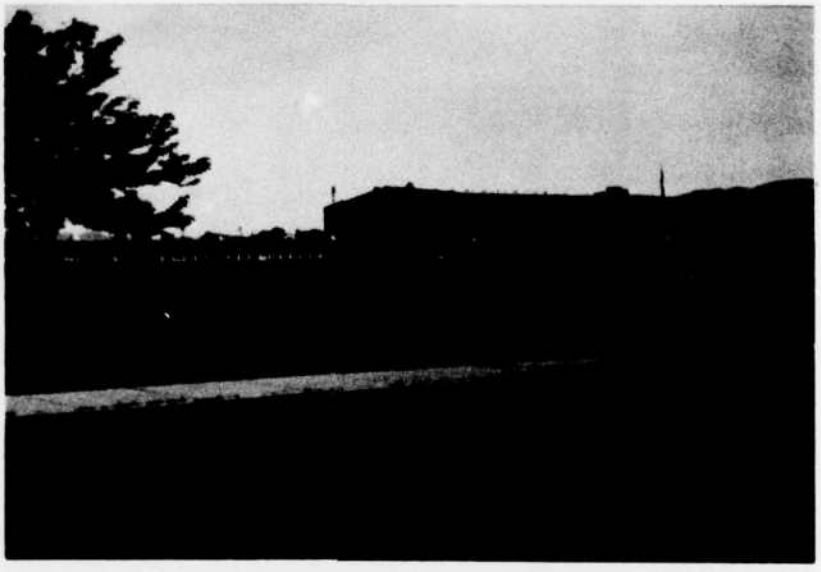
VIEW OF DOWNTOWN CANON CITY
FREMONT COUNTY, COLORADO

BUSINESS DISTRICT OF FLORENCE
FREMONT COUNTY, COLORADO

Figure 20



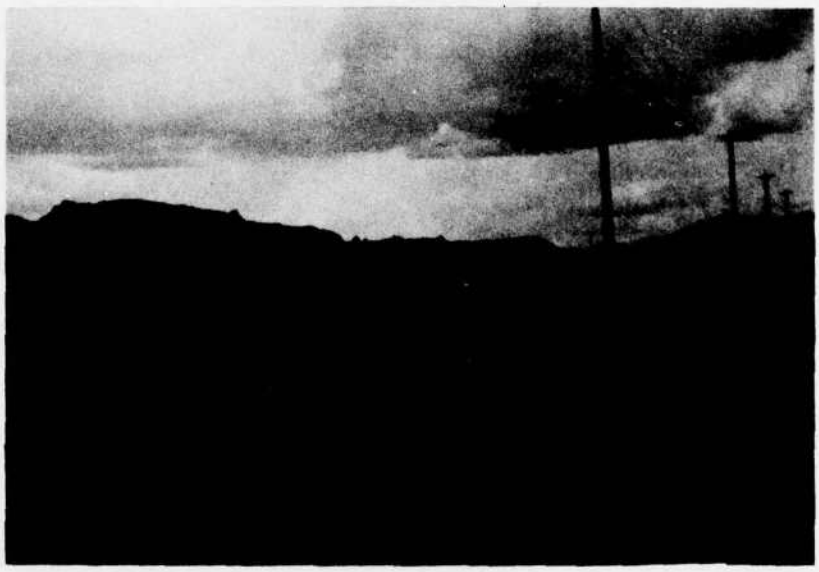
POTENTIAL BORROW AREA
WEST OF CANON CITY



FIELD AT CANON CITY HIGH SCHOOL
FAVORABLE FOR BUILDING EXPEDIENT SHELTERS

Figure 20 (Continued)

LOADING DUMP TRUCKS AT CANON CITY
SAND AND GRAVEL YARD



EXCAVATED BORROW AREA AT CANON CITY
SAND AND GRAVEL YARD

Figure 20 (Continued)

DUMP TRUCK STORAGE YARD
CANON CITY

COLORADO STATE HIGHWAY EQUIPMENT YARD
COLORADO SPRINGS

Figure 20 (Continued)

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UTILIZATION OF EQUIPMENT -CRISIS RELOCATION PROGRAM

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September, 1977 UNCLASSIFIED 150 Pages

The report presents guidelines and data enabling planners to analyze and determine requirements and adequacy of available equipment in providing fallout shelter protection for both host and risk area populations during a 3-day crisis build-up period. Manual tasks and other requirements are defined and examples given to illustrate procedures.

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DETACHABLE SUMMARY

UTILIZATION OF EQUIPMENT

CRISIS RELOCATION PROGRAM

Final Report

September, 1977

for

DEFENSE CIVIL PREPAREDNESS AGENCY

Washington, D.C. 20301

by

George E. Wickham
Henry R. Tiedemann

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San Francisco, California

Contract No. DCPA02-76-C-0306
Work Unit No. 3325I

DETACHABLE SUMMARY

EQUIPMENT UTILIZATION - CRISIS RELOCATION PROGRAM

An essential requirement of a Crisis Relocation Plan (CRP) is to provide fallout protection for both host area residents and relocatees as may be needed in the event that the crisis escalated into an attack. Shelter needs for any area can be determined by various survey methods. In all likelihood it will be found that existing facilities would not be adequate for this purpose, consequently it will be necessary to either upgrade (shield walls, floors and roofs) specified buildings or construct expedient type shelters. Protection factors (PF) of 40 or more can be achieved by shielding buildings with an average requirement of about one cubic yard of earth material for each available shelter space. Expedient shelters, which may afford higher PF's, require the handling of from 1.5 to 2.3 cu yds per space plus construction of the structural frame.

To provide this kind of shelter protection for large numbers of people within a crisis buildup period of three days requires the efficient utilization of equipment. Since upgrading requires less effort per space, the major use during a CRP would be in shielding existing buildings within designated host areas, which is essentially an earthmoving operation.

It is also necessary to consider the immediate need of equipment to perform rescue and other emergency tasks within the risk area should an attack occur. Emergency tasks normally

require the use of heavier type equipment than would be needed in the host areas.

The report describes both host and risk area equipment requirements and logistics as may be applicable to a CRP. It defines and details operations of excavating, loading, hauling and placing shielding material required for upgrading or construction of expedient shelters. Material could be obtained from sources adjacent to the structure being upgraded, or hauled from a common borrow pit. More effective utilization of equipment is achieved by using a common borrow pit whereby the dig - load - haul oprations can be concentraded at specific locations. Equipment use for the placing operation is less efficient and oftentimes dependent on production obtained by manual labor. Tables and guidelines needed to determine the types and quantities of work involved for typical host area tasks are provided.

Major types of equipment needed are dozers, loaders, shovels, backhoes and dump trucks. Their suitability for performing individual tasks is discussed and anticipated hourly production rates (cu yds/hr) established for a variety of situations. Both single units and groups of equipment are considered. Equipment operating requirements (fuel, lube, etc.) as well as supporting labor and other resources are defined and tables provided by which these requirements can be determined for all tasks. Knowing tasks and equipment capabilities it is possible to determine overall equipment requirements for a CRP.

Equipment would be found in both the host and risk areas. An inventorying method which can be used to determine amount of equipment available in both areas is discussed. Although possible; and in some situations necessary, the mutual utilization of equipment between host and risk areas would be fairly limited due to transportation and other problems.

In lieu of physical inventory, statistical data can be used to predict the amount of available equipment. This method, based on nationwide equipment manufacture statistics, was used to predict the available equipment for a prototype host area -- Fremont County, Colorado.

Pre-event planning procedures are discussed and a hypothetical example used to illustrate how host area tasks can be accomplished within a crisis build-up period by using predicted amount and type of available equipment. Methods involving general correlation of tasks and equipment capabilities and detailed matching of individual units to tasks are explained.

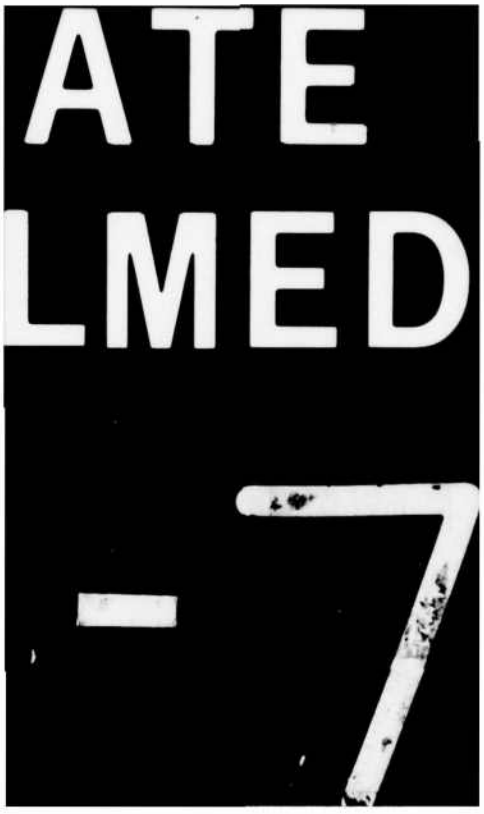
Initial effort should be directed toward the digging and delivery of shielding material to individual upgradable structures. Largest available equipment having greatest potential for high production performance should be used for this phase of the work. The placing operation, usually involving smaller units of equipment, would be performed in conjunction with the arrival of relocatees. Due to the concurrent use and mix of equipment and relatively inexperienced labor, it will be necessary to provide competent supervision throughout.

A physical inventory of equipment within Fremont County and a partial inventory in Colorado Springs (prototype risk area) was made to verify the predicted amount of equipment considered in the study examples. It showed significantly more equipment in Fremont County and approximately the same as predicted for Colorado Springs. The mixture (dozers - loaders, etc.) was similar to predictions in both areas.

The inventory showed, that for this particular area, available equipment would be more than adequate to perform all tasks needed to provide fallout shelter protection required by a CRP. However, it statistical data is correct, there must be other host areas which do not have enough equipment, thereby necessitating the transfer of equipment between risk and host areas. It is recommended that physical inventories be made in several other prototype areas to help refine or adjust the statistical method of predicting available equipment and make it more sensitive to such factors as population densities, geographic locations and local economic and industrial constraints.

Effective utilization of equipment in completing upgrading and expedient shelter tasks requires that fairly detailed analysis and planning procedures be established prior to the development of an international crisis. Each planner should prepare and test several simulations for his area to ascertain the adequacy of the equipment resource and to familiarize himself with overall CRP shelter requirements. This report provides general guidelines and specific data which can be used by the planner in this respect.

On the assumption that adequate planning has been completed, it appears likely that needed shelter capacities for most host areas can be achieved within a 3-day crisis period with the efficient use of available equipment.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